MODULAR POWER SUPPLIES
MODELS 61005C,61315D,63005C,63315D

HP PART NUMBER: 5950-1774

MICROFICHE NO.: 5950-1775

HEWLETT PACKARD

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MODULAR POWER SUPPLIES

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OPERATING AND SERVICE MANUAL FOR:
MODEL 61005C, SERIALS 1549A–00101 AND ABOVE
MODEL 61315D, SERIALS 1550A–00101 AND ABOVE
MODEL 63005C, SERIALS 1620A–00175 AND ABOVE
MODEL 63315D, SERIALS 1551A–00164 AND ABOVE

*** For instruments with serial numbers above those listed, a change page may be included. Refer to Appendix A for manual backdating changes applying to earlier instruments.**

HP Part No. 5950-1774

Printed: April, 1976

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 This manual covers two dc-input and two ac-input 110-watt switching-regulated power supplies. Each input type includes a single-output and a triple-output model. The Model 61005C uses a 42-volt to 56-volt (48-volt nominal) dc input to produce a single 4.75 to 5.25 volt (5-volt nominal) 22-amp dc output. The Model 61315D uses a 48-volt nominal dc input to produce three dc outputs, a 5-volt output with a load capacity of up to 18 amps and a pair of dual-tracking outputs adjustable from under ±12 volts to over ±15 volts with load capacities of up to 2 amps each. The negative dual output tracks the positive one within ±2%. The outputs of the Model 61315D can be operated anywhere within their 18-amp, 2-amp, and 2-amp individual current limitations provided that the total output power does not exceed the supply's 110-watt total output rating. (Figure 3-5 is a graph of the load sharing restrictions of the triple-output models.)

1-3 The two ac-input models have the same dc output ratings as the dc-input models. The single-output Model 63005C and the triple-output Model 63315D are designed to operate from a single-phase 48 to 63Hz source with a voltage range of either 87 to 127Vac or 180 to 250Vac. One of these input voltage ranges is selected by positioning jumpers on an external barrier strip.

1-4 The dc-input models are protected against an input overvoltage or an input polarity reversal. The ac-input models are SCR preregulated. All models use an advanced design 20kHz transistor switching regulator for their 5-volt outputs. The ±12 to ±15-volt outputs of the triple-output models are preregulated by the switching regulator for the 5-volt output and then regulated by linear transistor series regulators.

1-5 In all models, adjustable foldback current limit circuits protect all outputs against overload or short circuit damage by limiting the outputs to between 65% and 130% of their maximum ratings. Fixed overvoltage protection crowbar circuits are activated at 6 to 7 volts at the 5-volt output and at 16 to 18 volts at the ±12 to ±15-volt outputs. The crowbar circuits reduce all outputs to less than 2 volts if any one output exceeds its trip voltage.

1-6 The 5-volt and the ±12 to ±15-volt outputs are isolated from the chassis and from each other and may be grounded at the ground terminal provided or floated at up to 42 volts above ground.

1-7 SPECIFICATIONS

1-8 Table 1-1 lists detailed specifications for these power supplies.

1-9 INSTRUMENT AND MANUAL IDENTIFICATION

1-10 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits indicate the year (10=1970, 11=1971, etc.), the second two digits indicate the week, and the letter "A" designates the U. S. A. as the country of manufacture. The second part is the power supply serial number. A different sequential number is assigned to each power supply, starting with 00101.

1-11 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes define the differences between your instrument and the instrument described by this manual.

1-12 ORDERING ADDITIONAL MANUALS

1-13 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP Part number provided on the title page.

Table 1-1. Specifications, Models 61005C and 61315D (dc input), and Models 63005C and 63315D (ac input).

INPUT:

DC Input Models – 48Vdc nominal; range 42 to 56Vdc. Current, 5.5A max.

AC Input Models – 87 to 127Vac or 180 to 250Vac, single-phase, 48-63Hz. Voltage range changeable on external terminal block.

INPUT PROTECTION:

DC Input Models – A 6A fuse in series with the negative input lead is accessible at the terminal end of the supply. The supply is undamaged by any input between zero and 56 volts; the input will withstand a 60Vdc surge for 5 seconds. The supply is protected against a reverse input polarity by a shunt diode that blows the fuse.

AC Input Models – Input protected by an internal 5A fuse.

INPUT SURGE CURRENT:

DC Input Models – Less than 80A peak at turnon.

AC Input Models – Less than 20A peak ac inrush at turnon.

OUTPUT RATINGS: (Screwdriver voltage adjustments are accessible through holes in the panel.)

Single-Output Models (61005C and 63005C)

4.75 to 5.25Vdc	22A

Triple-Output Models (61315D and 63315D)

4.75 to 5.25Vdc	18A*
+11.40 to +15.75Vdc	2A*
–11.40 to –15.75Vdc	2A*

(* Maximum load currents cannot be obtained simultaneously. See Figure 3-5 for load sharing tradeoff.)

DUAL OUTPUT TRACKING ACCURACY:

Triple-Output Models – ±2%.

CARRYOVER TIME:

AC Input Models – Output voltage remains within 2% of specified nominal for more than 20msec while delivering full load current following removal of ac input power.

SOURCE EFFECT:

DC Input Models – Less than 0.1% for any change within the specified input voltage rating.

AC Input Models – Less than 0.02% for any change within the specified input voltage rating.

LOAD EFFECT:

All Outputs – Less than 0.1% for a load current change equal to the current rating of the output.

PARD (Ripple and Noise):

All Outputs – Less than 5mV rms and 40mV p-p (20Hz to 20MHz).

LOAD TRANSIENT RECOVERY TIME:

Less than 1.0msec (5V output) or 25μsec (±12 to ±15V outputs) for output recovery to within 1% of nominal output voltage following a load change from full to half load or vice versa.

DRIFT:

Change in output (dc to 20Hz) is less than 0.1% over an 8-hour interval following a 30-minute warmup.

TEMPERATURE COEFFICIENT:

All Outputs – Less than 0.015% output voltage change per degree Celsius over the operating range from 0 to 40°C at constant load and line voltage after 30 minutes warmup.

TEMPERATURE RANGES:

Operating Temperatures – 0 to 40°C ambient at full rated output. Above 40°C, derate output current linearly to 50% of maximum at 70°C.

Storage Temperatures – –55°C to +85°C.

COOLING:

Convection cooled. (In some applications, can be conduction cooled through surface at end of case after removing finned heatsink. Consult factory for recommendations.)

OVERTEMPERATURE PROTECTION:

Heatsink-mounted thermostat shuts off output(s) if supply overheats due to high ambient temperature. Thermostat automatically resets when unit cools to safe operating temperature.

OUTPUT OVERCURRENT PROTECTION:

Accessible screwdriver adjustment(s) are factory set to limit load current to approximately 120% (5V output) or 130% (±12 to ±15V outputs) of rated maximum current. Foldback current limit characteristics are shown in Figures 3-6 and 3-7. Adjustment range is approximately 65 to 130% of rated load current in single-output models and 65 to 150% in triple-output models.

OUTPUT OVERVOLTAGE PROTECTON:

A non-adjustable overvoltage crowbar reduces output(s) to less than 2 volts when trip level of 6 to 7 volts is exceeded at the 5V output or when 16 to 18 volts is exceeded at either 12 to 15V output. In the triple-output models, an overvoltage trip at any one output shuts down all three outputs.

Table 1-1. (Continued)

OUTPUT REVERSE VOLTAGE PROTECTION:

AC Input Models – Output(s) are protected from damage due to the application of a reverse polarity voltage.

REMOTE SHUTDOWN:

A contact closure or TTL (low) input between the 5V output's (–) or (–SEN) terminal and terminal E6 reduces the supply's output voltages to a low value. The outputs return to normal on opening the contact or switching to a high logic level.

REMOTE SENSING:

Remote sensing terminals are provided that will correct for a load lead voltage drop of up to 5% while maintaining nominal voltage at the load. The load is protected if the sensing leads are inadvertently opened.

DIELECTRIC WITHSTAND VOLTAGE:

DC Input Models –

Input to any output, 1000Vdc for 1 minute.
Input to case, 1000Vdc for 1 minute.
Any output to case, 500Vdc for 1 minute.

AC Input Models –

Primary to any output, 1500V rms for 1 minute.
Primary to case, 1500V rms for 1 minute.
Any output to case, 500Vdc for 1 minute.

INSULATION RESISTANCE:

DC Input Models –

Input to any output, 10 megohms minimum (500Vdc).
Input to case, 10 megohms minimum.
Any output to case, 10 megohms minimum.

AC Input Models – Between 5V output and ±15Vout-put, 10 megohms minimum.

Any output to case, 10 megohms minimum.

SAFETY STANDARDS:

Designed to conform to recommendations of IEC 348. Approved by UL for inclusion in their Recognized Compon-ent Index under Guide QQFU2, File E51529.

EMI CHARACTERISTICS:

DC Input Models – Comply with VDE 0875-1 LEVEL N.

AC Input Models – Comply with VDE 0871 LEVEL N.

DIMENSIONS:

(See outline diagrams in Section II.)

WEIGHT (Net/Shipping):

Model 61005C – 2.1kg (4.7 lb)/3.0kg (6.7 lb)
Model 61315D – 3.0kg (6.7 lb)/3.9kg (8.7 lb)
Model 63005C – 3.6kg (8.0 lb)/4.5kg (10 lb)
Model 63315D – 4.6kg (10 lb)/5.5kg (12 lb)

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, a claim should be filed with the carrier immediately. Also, a Hewlett-Packard Sales and Service office should be notified.

2-3 Mechanical Check

2-4 This check should confirm that there are no broken connectors and that the panel surfaces are free of dents and scratches.

2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for permanent installation or bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 Location and Cooling

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the instrument when it is in operation. At least 1/2 inch clearance at the bottom of the unit is recommended to permit proper air flow. The supply should be used in an area where the ambient temperature does not exceed 40°C. If operated at an ambient greater than 40°C, the supply's output current must be linearly derated down to 50% at 70°C.

2-11 It is also possible to cool this supply through conduction by removing its finned heatsink and mounting the rear surface of the supply to a suitable heat-conducting surface. Consult the factory for specific recommendations.

2-12 Mounting Orientation

2-13 Figures 2-1 through 2-4 provide outline and dimension information. As shown in these figures, four mounting holes are provided on the bottom of the supply and four more are available at the rear if the heat sink is removed. If these supplies are cooled by natural convection, the upright position is the only orientation recommended. If they are cooled by forced air or if the heatsink is removed and the supply is mounted to a heat-conducting surface, they may be mounted in any position.

2-14 Input Power Requirements

2-15 Models 61005C and 61315D. The Models 61005C and 61315D are designed for a nominal input of 48 volts dc. They can operate over an input range of 42 to 56 volts dc. Their maximum input currents are 5 amps and 5.5 amps, respectively, and they draw a maximum input power of 210 watts and 230 watts.

2-16 Models 63005C and 63315D. The Models 63005C and 63315D may be operated from an 87 to 127Vac or a 180 to 250Vac, single-phase, 48 to 63Hz power source and can be adapted for either of these input voltage ranges by the positioning of jumpers on terminals E1 through E5 on TB1. For 87 to 127V operation, jumper E1 to E2 and E4 to E5. For 180 to 250V operation, jumper E3 to E4 only. (When it is shipped, the supply's input jumpers are connected for 87 to 127Vac operation.) Both models draw a maximum input current of 4 amps. The maximum input power is 190 watts for the Model 63005C and 220 watts for the Model 63315D.

2-17 REPACKAGING FOR SHIPMENT

2-18 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped and provide the Authorized Return label necessary to expedite the handling of your instrument return. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

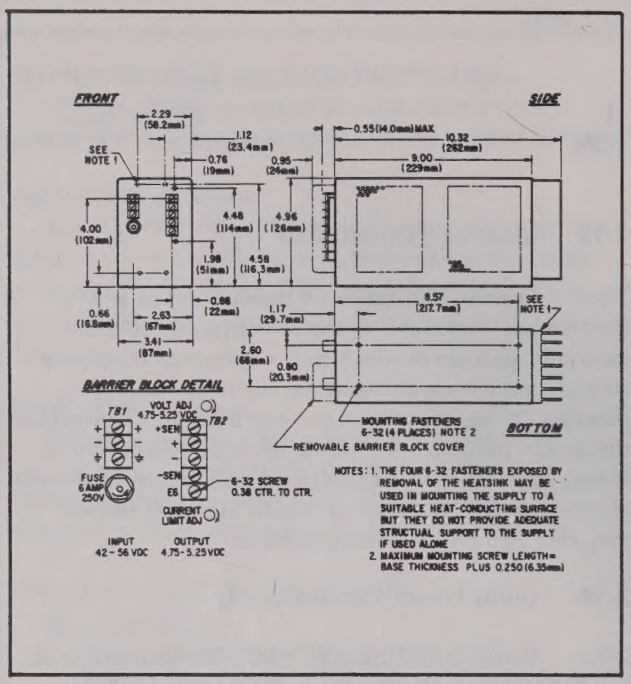


Figure 2-1. Outline Diagram, Model 61005C

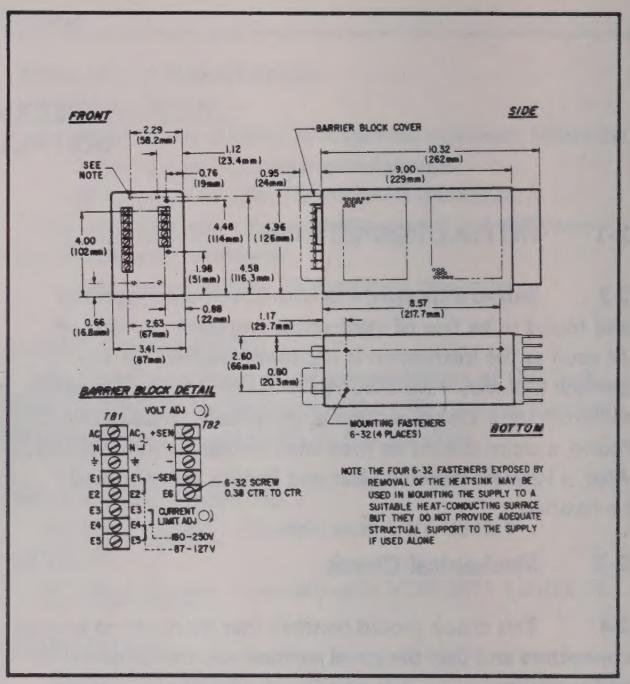


Figure 2-3. Outline Diagram, Model 63005C

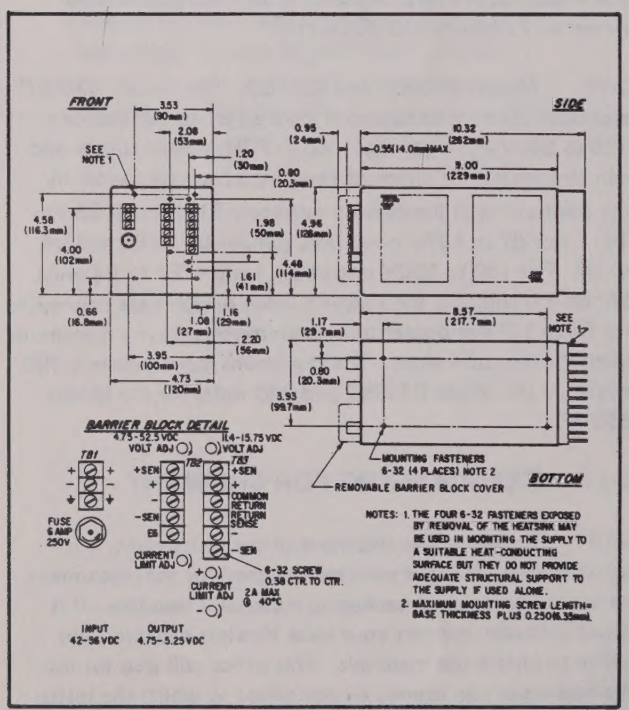


Figure 2-2. Outline Diagram, Model 61315D

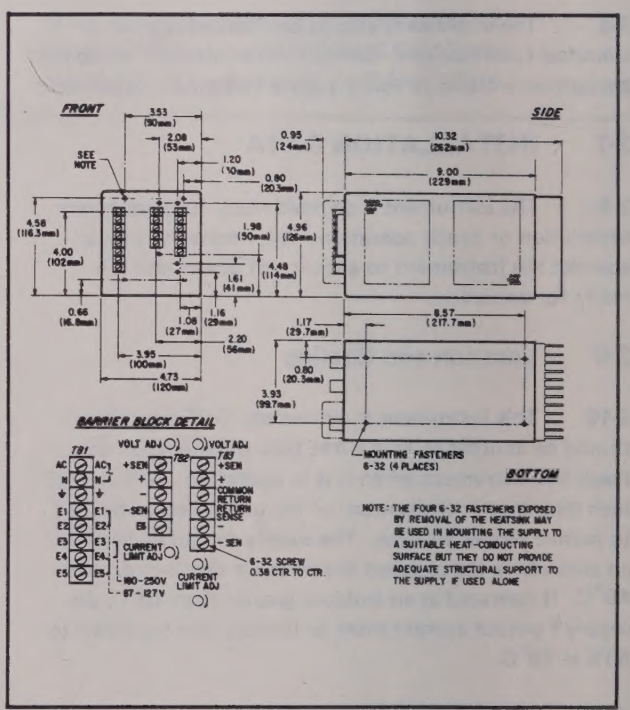


Figure 2-4. Outline Diagram, Model 63315D

SECTION III
OPERATING INSTRUCTIONS

3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure serves as a brief check that the supply is operational. This procedure or the more detailed performance test of paragraph 5-6 should be followed when the instrument is received and before it is connected to any load equipment.

PREPARATION

a. Before connecting input power to the ac-input models, check that jumpers on terminals E1 through E5 of TB1 are connected appropriately for the ac supply voltage to be used. (See paragraph 2-16.)

b. Connect all remote sensing terminals to the corresponding output terminals as shown in Figure 3-1.

c. Connect unit to input power source. Use the AC, N, and ground (⏚) terminals on an ac-input unit or the (+), (–), and ground terminals on a dc-input unit.

VOLTAGE CHECKS

d. Check the voltage of the 5V output between terminals (+) and (–) on TB2 and, using a small screwdriver to turn the VOLT ADJ control, set the output to the desired value within its 4.75 to 5.25V range.

e. (Triple-output models only.) Check the voltages of the positive and negative 11.4 to 15.75V outputs by measuring from (+) to COMMON RETURN and from COMMON RETURN to (–) on TB3. They should differ from each other by no more than ±2%. Turn the VOLT ADJ control to set these outputs to the desired voltage.

CURRENT LIMIT CHECKS

f. To check the operation of the current limit circuit for the 5V output, connect the test setup shown in Figure 5-2 to the output, using a variable load resistor for R_L that can be adjusted from about 0.15Ω to about 0.5Ω. The load resistor must be able to dissipate 110 watts. Set R_L to its maximum resistance and apply power to the supply. Decrease the resistance of R_L gradually while observing the output current indicated by the DVM. The current should increase to some maximum value, which is the current limit setting, and then begin to decrease. To adjust the current limit setting, see paragraph 5-46.

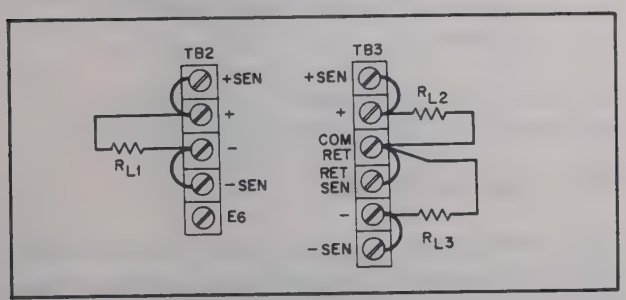


Figure 3-1. Load Connections, Local Sensing

g. (Triple-output models only.) Check the operation of the current limit circuit for the positive 11.4 to 15.75V output by the method described in (f) above, but using a variable load resistor with an adjustment range of about 4Ω to 15Ω and a 50W power rating. Repeat for the negative output. To adjust the current limit settings, see paragraph 5-46.

OVERVOLTAGE PROTECTION CHECKS

h. Because the supply's output voltage adjustment ranges are limited and the overvoltage trip circuits are not adjustable, checking the overvoltage trip circuits requires the use of an external power supply. The supply needed for checking the overvoltage trip for the 5V output should be able to supply 5 to 7Vdc at a current of at least 2 amps. To avoid causing damage to the supply under test, the external supply's maximum available current should be no more than 5 amps. To check that the overvoltage trip circuit for the 5V output is operational, energize the external supply and adjust its output to 7 volts. Energize the supply being tested and then momentarily connect the output of the external supply across its 5V output terminals, negative to negative and positive to positive. After disconnecting the external supply, check for the presence of voltage at the outputs of the supply under test. All outputs should be at zero volts. Deenergize the supply under test for 10 seconds and then restore power. Check that all outputs have returned to normal.

i. (Triple-output models only.) A similar method is used for checking the ±11.4 to ±15.75V outputs of the triple-output models. An external supply is needed that can provide 15 to 18Vdc at a current of at least 0.5 amps. Its maximum available current should be no more than 5 amps. To check the overvoltage trip circuit for the positive 11.4 to 15.75V output, energize the external supply and adjust its output to 18 volts. Energize the supply being tested and then momentarily connect the output of the external supply across its (+) and COMMON RETURN output terminals, positive to positive. After disconnecting the external supply, check that all outputs of the supply under test have dropped to zero volts and that deenergizing the supply for 10 seconds restores the outputs to normal.

j. (Triple-output models only.) To check the overvoltage trip circuit for the negative 11.4 to 15.75V output, repeat the procedure given in step (i) above, except connect the external supply across the (—) and COMMON RETURN output terminals of the supply under test, negative to negative.

REMOTE SHUTDOWN

k. Verify that connecting a jumper between terminals E6 and (—SEN) on TB2 reduces the supply's output voltage(s) to a low level and that disconnecting the jumper restores all output voltages to normal.

3-3 If this brief checkout procedure or later use of the supply reveals a possible malfunction, see Section V of this manual for detailed test, troubleshooting, and adjustment procedures.

3-4 OPERATION

——— CAUTION ———

Before applying power to one of the ac-input models, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used.

3-5 The following paragraphs discuss the various operating modes and features of the Models 61005C, 61315D, 63005C, and 63315D. Their 5V outputs can be used with local or remote voltage sensing. The ±11.4 to ±15.75V outputs of the triple-output models can be used as a dual output supplying equal positive and negative voltages, or they can be connected to provide a single 22.8 to 31.5-volt output. Local or remote sensing can be used with either the dual or single load connections.

3-6 The DC Power Supply Handbook, Application Note 90A, is a useful source of additional information on using regulated power supplies effectively. This 138-page handbook includes chapters on operating principles, ac and load connections, optional operating modes, and performance measurements and is available at no charge from your local HP sales office. The address of your local sales office can be found in the back of this manual.

3-7 Connecting Loads

3-8 Figure 3-1 shows the strapping arrangement for connecting loads to the supply using local voltage sensing and supplying two separate loads from the ±11.4 to ±15.75V outputs. The positive (master) supply powers R_{L2} and the negative (slave) supply powers R_{L3}. As the VOLT ADJ control for the dual outputs is adjusted, the slave supply's output tracks that of the master within ±2%. Either terminal of the 5V output and any one terminal of the dual output may be grounded, if desired, either at the supply's ground (⏚) terminal or at the load. (See paragraph 3-12.)

3-9 To use the dual outputs to supply 22.8 to 31.5 volts to a single load, use the strapping arrangement shown in Figure 3-2. Either the (+) or (—) output terminal may be grounded, as required. (See paragraph 3-12.)

3-10 Each load should be connected to the proper supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the supply. Each pair of connecting wires should be as short as possible, should be of adequately heavy gauge, and should be twisted or shielded to reduce noise pickup. If shielded wire is used, connect one end of the shield to the power supply ground terminal and leave the other end unconnected.

3-11 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals by a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. Remote sensing should be used under these circumstances. (See paragraph 3-14.)

3-12 Grounding

3-13 The 5V output can be used either as a positive or a negative supply by grounding one of its output terminals or one end of the load.

WARNING

Ground at only one point in the setup and always use two wires to connect the load to the supply. This eliminates the possibility of load current return paths through the input ground line which could open the chassis ground path and create a hazardous condition.

If neither output bus is grounded, the outputs of this supply can be operated at up to 42Vdc above ground.

3-14 Remote Sensing

3-15 Remote sensing is used to maintain good regulation at the load by reducing the degradation in regulation that would occur due to the voltage drop in the leads between the power supply and the load. For reasonable load lead

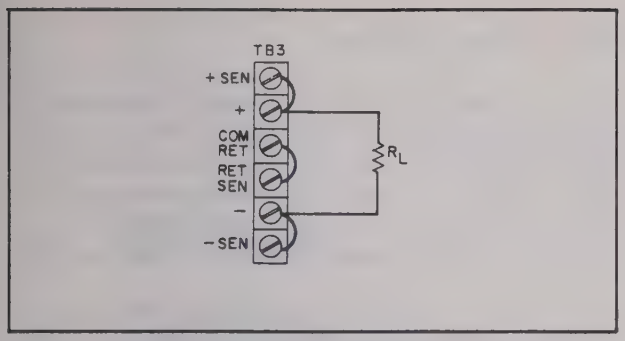


Figure 3-2. Single Load, Local Sensing

lengths, remote sensing greatly improves the performance of the supply. However, if the load is located a considerable distance from the supply, added precautions must be observed to obtain satisfactory operation.

3-16 Because the voltage drop in the load leads subtracts directly fromthe available output voltage, it is recommended that the total drop in both load leads not exceed 5% of the supply's nominal output voltage. The leads from the sensing terminals to the load carry much less current than the load leads, so these leads need not be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pickup.

3-17 Figure 3-3 shows the strapping arrangement for connecting loads to the supply using remote sensing. When the loads on the dual outputs of a triple-output model are located a considerable distance from each other, the COMMON RETURN load lead and the RETURN SENSE lead should be connected together at a remote sensing point that is equidistant from the two loads. This ensures that the regulation characteristics of both outputs will be equal.

3-18 Figure 3-4 shows the connections necessary for powering a single load from the dual output using remote sensing. The (+SEN) and (–SEN) sensing leads should be connected as close as possible to the load.

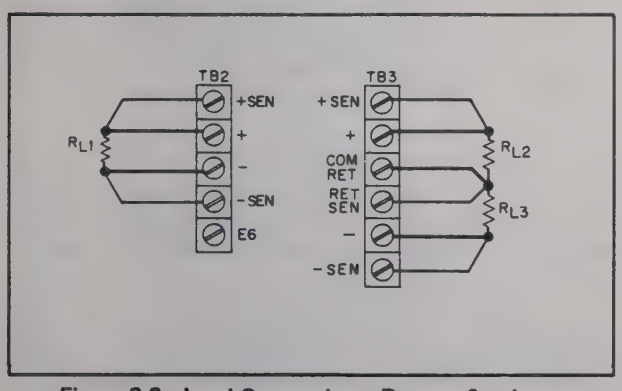


Figure 3-3. Load Connections, Remote Sensing

3-19 Output Ratings

3-20 Models 61005C and 63005C. These single-output models are capable of providing 22 amps at 5V ±0.25V at ambient temperatures up to 40°C. Above 40°C, the output current must be linearly derated to 50% at the maximum operating temperature of 70°C.

3-21 Models 61315D and 63315D. Individually, the maximum output currents of these triple-output models are 18 amps at the 5V ±0.25V output and 2 amps at each of the 11.4 to 15.75V outputs. These maximum currents are not available simultaneously, though, due to the 110W total output rating of the supply. Figure 3-5 illustrates the load sharing tradeoff between the 5V and the ±11.4 to ±15.75V outputs. Above 40°C, these output currents must be linearly derated to 50% at the maximum operating temperature of 70°C.

3-22 Current Limiting

3-23 The current limiting characteristics of these supplies are shown in Figures 3-6 and 3-7. The current limit circuits in these supplies provide foldback limiting, which reduces the output current as the voltage decreases. This results in a short-circuit current that is less than the maximum available at the rated output voltage. The circuits are self-restoring and return the output voltage to normal when the overload is removed. Figures 3-6 and 3-7 show the approximate factory settings and adjustment ranges for the current limiting circuits. Changing the setting of the control affects the maximum output current as shown but has no effect on the short circuit current. Procedures for adjusting the operating points of the current limit circuits are given in paragraph 5-46.

3-24 When adjusting the current limit, ensure that the new set point is at least 20% above the expected operating current. Operating the supply too close to the current limit set point may degrade performance.

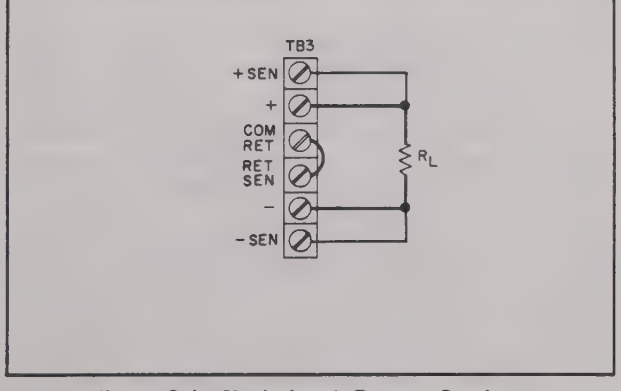


Figure 3-4. Single Load, Remote Sensing

3-25 Since, in the dual outputs of the triple-output models, the voltage of the slave (negative) supply depends on that of the master (positive) supply, the occurrence of current limiting in the master supply reduces the voltage of both outputs. If a single load is connected across both outputs as shown in Figures 3-2 and 3-4, the initial current limit point is determined by the current limit circuit with the lower setting and the short circuit current is governed by the master supply.

3-26 Overvoltage Protection

3-27 Each output of this supply has an independent fixed crowbar circuit to protect sensitive loads from excessive voltages. The circuit for the 5V output is activated between 6 and 7 volts and the ones for the dual outputs of the triple-output models are activated between 16 and 18 volts. After a crowbar circuit fires, all outputs of the supply fall to zero volts. To restore normal operation after an overvoltage shutdown has occurred, ac power must be removed from the supply for at least 10 seconds. If the crowbar trips again when power is restored, refer to the troubleshooting information in Section V of this manual.

3-28 Remote Shutdown

3-29 If remote control of the power supply is required, all outputs of the supply can be operated remotely through a contact connected from terminal E6 on TB2 to either the (—) or the (—SEN) terminal of the 5V output. Closing this contact reduces all outputs to a low level.

3-30 The remote shutdown input can also be controlled by a TTL digital input signal. Use the (—) or (—SEN) terminal of the 5V output as the common input and apply TTL logic levels to terminal E6. A low logic level shuts down the supply; a high logic level input restores the outputs.

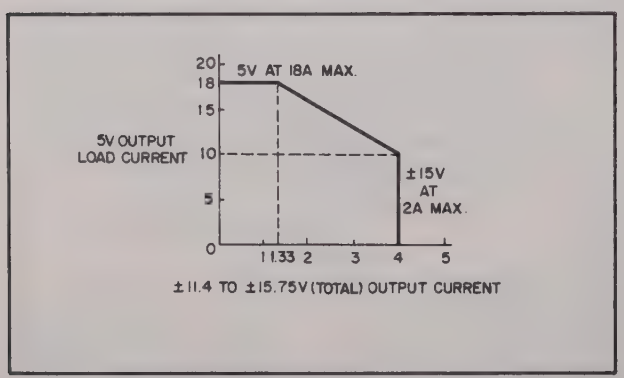


Figure 3-5. Load Sharing Tradeoff, Models 61315D and 63315D

3-31 Series Operation

3-32 Either the 5V or the ±11.4 to ±15.75V outputs of two or more supplies can be connected in series to obtain a higher voltage than is available from a single supply. The number that can be connected in series is limited by the restriction against operating these supplies with their outputs at a potential greater than 42 volts above ground.

3-33 Notice that series operation creates the possibility of a reverse voltage being applied across the output terminals of a deenergized supply that is in series with an energized one. If this occurs, the resulting reverse current flows through A2U2 in a 5V output or diodes A3CR1 or CR2, which protect the ±15V outputs against reverse voltage. These diodes provide reverse voltage protection at currents up to the current rating of the respective power supply output.

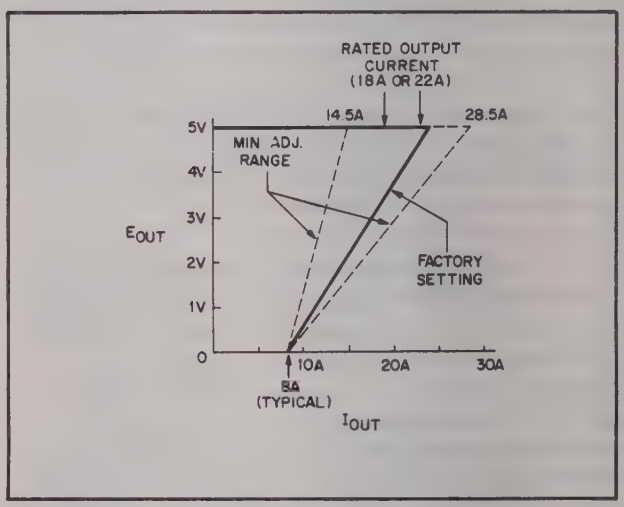


Figure 3-6. 5V Output, Current Limit Characteristics

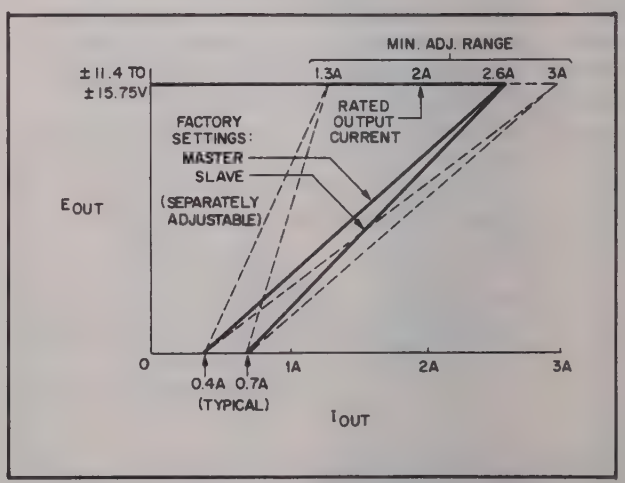


Figure 3-7. Models 61315D and 63315D, Dual Output, Current Limit Characteristics

SECTION IV
PRINCIPLES OF OPERATION

4-1 INTRODUCTION

4-2 The four power supply models included in this manual are composed of four different combinations of the circuit boards shown in the simplified schematic of Figure 4-1. The single-output models each use two circuit boards. The dc-input Model 61005C uses the A1 board shown at the upper left of the figure along with the A2 board at the upper right, and the ac-input Model 63005C uses the A1 board at the lower left and the same A2 board. The two triple-output models, the dc-input 61315D and the ac-input 63315D, each add the A3 board shown at the lower right to the pair of boards used in the corresponding single-output model.

4-3 The A1 board used in the dc-input models contains an LC filter, a 20kHz switching regulator, and an input overvoltage comparator that protects the regulator from an excessive input voltage by turning off the clock that times its operation. The regulator's control signals are received from the A2 board. An output overvoltage trip signal, also received from the A2 board, shuts down the regulator by removing power from the clock.

4-4 The A1 board used in the ac-input models contains an input RFI filter and an SCR preregulator whose 100-volt dc output provides input power to a 20kHz switching regulator. The switching regulators used in the dc-input and the ac-input models are similar. In both circuits, a recurrent pulse signal from the clock turns on a switching transistor connected in series with the primary of a transformer located on the A2 board. Following each turn-on pulse, a pulse received from a pulse-width modulator on the A2 board turns off the transistor. The switching transistor remains turned-off until the next clock pulse turns it on again. The pulse-width modulator controls the duration of the switching transistor's conduction time to regulate the 5-volt dc output of the supply.

4-5 On the A2 board, the 20kHz output from the switching regulator transformer secondary is rectified and filtered to produce the supply's 5-volt regulated dc output. Circuits on the A2 board provide input signals to the pulse-width modulator that enable the modulator to regulate the output voltage, limit the output current, and turn on the power supply output(s) gradually when input power is first applied. A photo-isolator on the A1 board couples the pulse-width modulator's output pulses to the switching regulator. The A2 board also includes an overvoltage protection crowbar circuit for the 5-volt output. When this circuit detects an output overvoltage, it shorts the output and sends an overvoltage trip pulse to the clock shutdown switch on the A1 board.

4-6 The A3 board is used only in the triple-output models. This board contains two linear transistor series regulators connected in a positive-and-negative master-slave configuration. The negative supply uses the positive output as its reference voltage so that both outputs track within ±2% as they are varied over their ±11.4 to ±15.75-volt range by a single screwdriver adjustment. The 20kHz outputs from two additional secondary windings on the switching regulator transformer are rectified and filtered to provide the dc inputs to these series regulators. Each regulator is equipped with output current limit and overvoltage protection crowbar circuits. The overvoltage circuits on the A3 board generate a trigger that trips the clock shutdown switch on the A1 board to turn off the switching regulator when an overvoltage condition occurs. Turning off the switching regulator reduces the voltage at all three outputs to zero.

4-7 SIMPLIFIED SCHEMATIC DIAGRAM DISCUSSION

4-8 The following discussion of the overall operation of these power supplies is based on the simplified schematic of Figure 4-1. For detailed circuit information, refer also to Figures 7-4, 7-6, 7-8, and 7-9.

4-9 DC-DC Converter (A1 Board, Models 61005C and 63315D Only)

4-10 A normally back-biased diode connected across the input of the dc-input A1 board blows the input fuse to protect the regulator from being damaged by the application of a wrong polarity input. The regulator is also protected against an excessive input voltage by an input overvoltage comparator circuit that turns off the switching regulator by sending a reset signal to the 20kHz clock if the input exceeds 64 volts. When the input voltage returns to within normal limits, normal operation resumes automatically. Dc input power is filtered by an LC filter and applied to the 20kHz switching regulator.

4-11 **20kHz Switching Regulator.** The supply's 5V

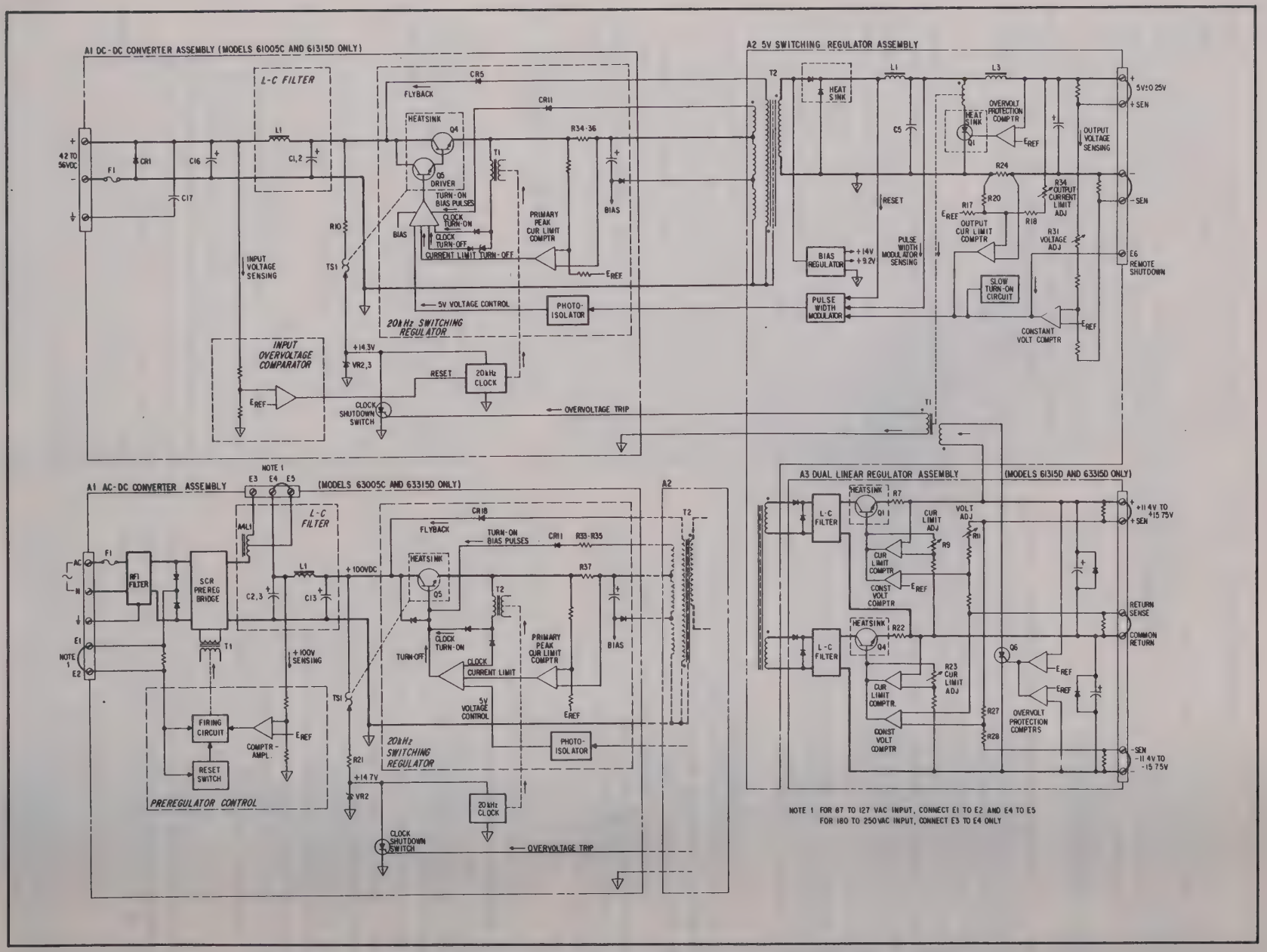


Figure 4-1. Simplified Schematic Diagram, Models 61005C, 61315D, 63005C, and 63315D

output is regulated by a transistor switching regulator connected in series with the 42 to 56-volt dc input source and the primary winding of power transformer A2T2 on the A2 board. The 5V output is regulated by controlling the percentage of the time that switching transistor A1Q4 conducts. An IC timer in the 20kHz clock circuit controls the transistor's switching rate, and a pulse width modulator located on the A2 board controls its on-time.

4-12 The clock establishes the basic timing cycle for the regulator by generating an alternating sequence of switching transistor turn-on and turn-off pulses that are conducted to the base of A1Q4 through pulse transformer A1T1. The maximum duty cycle of the switching transistor is 60%. Each time that a turn-on clock pulse switches A1Q4 on, a turn-on bias pulse produced by a regenerative bias winding of A2T2 keeps A1Q4 on until a turn-off signal appears.

4-13 Following each clock turn-on pulse, there are three signals that can turn off the switching transistor. They are:

(1) a voltage control pulse from the pulse width modulator,

(2) a primary peak current limit pulse from a current limit comparator in the switching regulator,

(3) a turn-off pulse from the clock.

The first of these three signals to appear after each clock turn-on pulse turns A1Q4 off until the next clock turn-on pulse initiates the next operating cycle.

4-14 Normally, it is the voltage control pulse that turns off A1Q4. An optically coupled isolator in its signal path provides electrical isolation between primary and secondary circuits. The timing of this pulse controls the voltage of the 5V output. A tendency for the output voltage to decrease is compensated by an increase in the delay between the clock turn-on pulse and the subsequent turn-off pulse from the pulse width modulator. If the output tends to increase, the delay is reduced. Slow turn-on control, output current limit, and remote shutdown signals are also communicated through this path from the A2 board. The generation of these signals is covered in the discussion of the A2 board.

4-15 The second switching transistor turn-off signal listed in paragraph 4-13 is produced by a fixed current limit comparator that monitors the peak current through A1R34 through A1R36 during each pulse that A1Q4 conducts and immediately turns off A1Q4 if this current exceeds a preset level. This current limit circuit on the primary side of the transformer serves as a backup to the protection provided by an adjustable output current limit circuit on the secondary side. The primary peak current limit circuit has a higher set point than the one on the secondary side and functions solely to protect the switching transistor.

4-16 The third turn-off signal listed in paragraph 4-13, the clock turn-off pulse, limits the maximum on-time of A1Q4 to 30 microseconds of each 50μsec operating cycle to avoid transformer saturation.

4-17 Between the time a turn-off signal ends A1Q4's conduction interval and the time the clock turn-on pulse turns A1Q4 on again, the collapsing field of transformer A2T2 generates a current pulse in a flyback winding which CR5 conducts to return this energy to capacitors A1C1 and A1C2 at the input to the switching regulator. This keeps the transformer core out of saturation by resetting it before the next operating cycle begins.

4-18 The clock receives its +14.3V operating bias from a shunt zener regulator composed of R10, VR2, and VR3. An excessive A1Q4 switching transistor heatsink temperature opens thermal switch TS1 to interrupt the dc supply to the clock bias regulator. This stops the clock to leave A1Q4 safely turned off. TS1 remains open until the heatsink has cooled to a safe operating temperature.

4-19 In case of an overvoltage condition at the 5V output of one of the single-output models or at any of the outputs of a triple-output model, an overvoltage trip pulse fires an SCR connected as a clock shutdown switch that shorts the 14.3V bias supply to the clock to shut down the switching regulator.

4-20 AC-DC Converter (A1 Board, Models 63005C and 63315D Only)

4-21 Although the 20kHz switching regulator circuits in the dc-input models and in the ac-input models are not identical, they are sufficiently similar that the description in paragraphs 4-11 through 4-19 applies equally well to both circuits except for a few differing component designations. In the ac-input models, the dc input to the switching regulator is provided by an SCR preregulator that converts an ac input of 87 to 127 volts or 180 to 250 volts to a regulated 100 volts dc.

4-22 Preregulator. The ac input to the A1 board is connected through an RFI filter directly to the input of a preregulator bridge composed of two diodes and two SCRs. The firing angle of the SCRs is controlled by the preregulator control circuit so that their full-wave rectified output, after being filtered by a 2-section LC filter, averages 100 volts dc. The preregulator control circuit consists of a comparator-amplifier that compares the voltage at its input to a zener reference voltage and controls the firing delay of a programmable unijunction transistor in the

firing circuit. During each half-cycle of the ac line input, one output pulse from the unijunction is coupled to the SCR gates by pulse transformer A1T1. If the 100V output tends to increase, the comparator-amplifier reduces the conduction angle of the SCRs. If the voltage tends to decrease, the conduction angle is increased. The reset switch discharges the timing capacitor in the firing circuit at the end of each half-cycle of the ac line input.

4-23 The supply is designed for two ac line voltage ranges (87 to 127Vac and 180 to 250Vac) and can easily be converted from one to the other by changing jumper positions on terminals E1 through E5 on an external terminal block.

4-24 5V Switching Regulator Assembly (A2 Board)

4-25 On the A2 board, the 20kHz ac voltage at one secondary of switching regulator power transformer A2T2 is half-wave rectified and then filtered by a 2-section LC filter to provide a regulated 5V dc output. This board also contains circuits that regulate the output voltage, turn on the switching regulator slowly when power is first applied, limit the output current, and shut down the supply if an overvoltage occurs at the 5V output. The output voltage regulation, slow turn-on, and output current limit functions are controlled through input signals to the pulse width modulator, whose output is transmitted through the optically coupled isolator on the A1 board to the switching regulator transistor.

4-26 **Voltage Regulation.** Each output pulse from the pulse width modulator causes the switching regulator transistor to stop conducting. Thus, the output voltage is regulated by controlling the duration of this transistor's conduction intervals. The pulse width modulator controls the timing of its output pulses by comparing two input signals. One of them is a dc level received from the output of the constant voltage comparator. This signal varies with the difference between the supply's output voltage and that of a fixed reference. An increase in the supply's output voltage changes this dc level in the negative direction. The pulse width modulator compares this dc level to a combined dc and ripple signal taken from the output of the first section of the LC filter.

4-27 When the clock on the A1 board turns the switching regulator transistor on, the positive voltage at the secondary of transformer A2T2 begins charging A2C5 through inductor A2L1. The positive-going ramp voltage waveform on these capacitors and the dc level from the constant voltage comparator are both attenuated and applied to two inputs of a comparator within the pulse width modulator. The pulse width modulator's output pulse to the isolator is produced each time the dc plus ripple voltage input from A2C5 exceeds the dc level input from the constant voltage comparator. The input pulse to the isolator turns on a light emitting diode (LED) which turns on a phototransistor. When the phototransistor conducts, it turns off the switching regulator transistor.

4-28 Now that the switching regulator transistor has been turned off, the negative-going voltage at the input to inductor A2L1 resets the pulse width modulator for the next operating cycle, which begins when the clock turns on the transistor again.

4-29 If the voltage at the 5V output tends to decrease, the dc level input to the pulse width modulator increases. As a result, it takes slightly longer for the ramp waveform of the ripple voltage to exceed this higher dc level at the comparator inputs. Thus, the delay before the switching regulator transistor is turned off is increased slightly to increase its conduction time and compensate for the decreased output.

4-30 **Slow Turn-On Control.** The slow turn-on control circuit prevents an output voltage overshoot from occuring and actuating the overvoltage trip circuit when power is first applied to the supply. The circuit consists of an r-c network that slows down the initial rise in voltage of the dc level input to the pulse width modulator from the constant voltage comparator. This causes the switching regulator to bring up the output voltage smoothly to its nominal value.

4-31 **Output Current Limiting.** The 5V output is protected against an overload or short circuit by an adjustable foldback current limit circuit that reduces the output voltage and current as an overload increases. The current limit characteristics of the 5V output are shown in Figure 3-6 or 3-7. To obtain these current limit characteristics, the output current limit comparator compares the voltage developed across current sampling resistor R24 to a reference voltage developed across R20. When the voltage across R24 exceeds this reference, the output of the comparator reduces the dc level input to the pulse width modulator to reduce the supply's output. The resulting reduction in output voltage decreases the contribution made to the reference voltage across R20 by current from the positive output line through R34 and R18. This reduces the output current limiting point as the output voltage decreases. If the output is short-circuited, the circuit reduces the output current to the value determined by the reference voltage developed by the current through R17 alone. For this reason, output current limit adjust R34 affects the maximum output current while leaving the short-circuit current fixed.

4-32 Remote Shutdown. A contact closure or TTL input signal applied between remote shutdown terminal E6 and either the negative output or the negative sensing terminal of the 5V supply reduces all outputs of the supply to a low level. This input signal shuts down the outputs by lowering the dc level input to the pulse width modulator. The outputs of the supply return to normal on removal of the remote shutdown input signal.

4-33 Overvoltage Protection. An overvoltage protection circuit monitors the 5V output and fires SCR A2Q1 if the voltage exceeds a preset trip level of 6 to 7 volts. When A2Q1 fires, it immediately discharges the filter capacitors across the 5V output to reduce the output to less than 2 volts. At the same time, a current pulse from A2T1 fires the clock shutdown switch SCR on the A1 board to remove power from the clock and shut off the switching regulator transistor. This reduces all output voltages to zero. In order to restore the supply to operation, its input power must be removed for a minimum of 10 seconds and then reapplied.

4-34 Dual Linear Regulator Assembly (A3 Board, Models 61315D and 63315D Only)

4-35 Two series-transistor regulators on the A3 board provide dual tracking outputs of ±11.4 to ±15.75 volts. The input power to these regulators is obtained from two additional secondary windings of transformer A2T2 and is half-wave rectified and filtered on the A3 board.

4-36 Voltage Regulation. The regulators for the positive and negative outputs are similar except that the one for the positive output compares its output voltage to that of a zener reference while the one for the negative output compares the voltage at the COMMON RETURN output terminal to the voltage at the junction of two equal resistors, A3R27 and A3R28, which are connected across the positive and negative outputs. This is why the output voltage of the negative (or slave) supply matches that of the positive (or master) supply within a ±2% tolerance and a single voltage adjustment control, A3R11, controls both outputs. The constant voltage comparators regulate the outputs of the supply by controlling the conductance of series regulator transistors A3Q1 and A3Q4.

4-37 Output Current Limiting. A current limit comparator for each regulator monitors the voltage drop across current sampling resistor R7 or R22 and compares it to an adjustable reference voltage across R9 or R23 that is derived from the regulator's output. If the voltage drop across the current sampling resistor exceeds the reference voltage, the comparator's output signal to the series regulator causes the output voltage and current to be reduced. This reduction in the output voltage reduces the current limit circuit's reference voltage to produce the foldback current limit characteristic shown in Figure 3-8. Because of the dual tracking interconnection between the positive and negative supplies, the output voltages of both are reduced if the positive output is overloaded.

4-38 Overvoltage Protection. To protect loads on the ±15V outputs against overvoltage, an overvoltage protection comparator monitors each output and fires an SCR connected across the ±15V outputs if either exceeds the preset trip level of 16 to 18 volts. When SCR A3Q6 fires, it shorts the ±15V outputs and simultaneously sends an overvoltage trip pulse through A2T1 to the clock shutdown switch on the A1 board to shut down the clock. Thus an overvoltage condition at any of the triple output supply's three outputs shuts down the entire supply.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance test of paragraph 5-6 can be made. This test is suitable for incoming inspection. Section III contains a quick but less comprehensive checkout procedure that can be used in lieu of the performance test if desired.

5-3 If a fault is detected in the power supply while making the performance test or during normal operation, proceed to the troubleshooting procedure in paragraph 5-33. After troubleshooting and repair, repeat the performance test to ensure that the fault has been properly corrected and that no other faults exist. Before performing any maintenance check, turn on the power supply and allow a half-hour warm-up.

5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Digital Voltmeter	Sensitivity: 100μV full scale (min.). Input Impedance: 10 megohms (min.).	Measure DC voltages: calibration procedures	HP 3450A
Variable Voltage Transformer	Range: 90-130Vac Equipped with voltmeter accurate within 1 volt	Vary AC input	– – – –
Oscilloscope	Sensitivity: 5mV/cm. Bandwidth: 20MHz (min.) Differential input	Display transient response and ripple and noise waveforms.	HP 180A with 1821A, and 1801A or 1803A plug-ins.
Multimeter	±2% DC accuracy	Resistance checks.	Simpson Model 269
Repetitive Load Sw.	Rate: 60Hz, 2μsec rise and fall time.	Measure transient response.	See Figure 5-4.
Resistive Loads	Tolerance: ±5%.	Power supply load resistor (fixed resistor or rheostat).	James G. Biddle ("Lubri-Tact" Rheostat).
Current Sampling Resistor (Shunt)	Accuracy: 1%	(a) Measure 5V output current. (b) Measure ±15V output current	(a) Empro Shunt, A-50-50. (b) 0.1Ω resistor, HP Part No. 0811-2061.
Regulated dc power supply	Adjustable output, 5 to 20Vdc at 2A (min.). Current limited to 5A or less.	Output overvoltage protection checks (para. 3-2).	– – – –
Variable dc power supply	Adjustable from 40 to 70Vdc at 0 to 6A (min.).	Source effect and input overvoltage testing of dc-input models.	– – – –

5-6 PERFORMANCE TEST

5-7 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated to check the operation of the instrument after repairs. The tests are performed using the specified nominal input voltage for the unit. If the correct result is not obtained for a particular check, proceed to troubleshooting (paragraph 5-33).

CAUTION

Before applying power to either of the ac-input models, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used.

5-8 General Measurement Techniques

5-9 Connecting Measuring Devices. To achieve valid results when measuring the load effect, PARD (ripple and noise), and transient recovery time of the supply, measuring devices must be connected across the supply's sensing terminals. If a measurement were made across the load, it would include the impedance of the leads to the load. This impedance can easily be several orders of magnitude greater than the supply impedance, and would thus invalidate the measurement. To avoid mutual coupling effects, each measuring device must be connected directly to the supply's sensing terminals by separate pairs of wires.

5-10 Output Current Measurements. Accurate output current measurements can be made by inserting a low resistance current sampling resistor in series with a load resistor of appropriate resistance and wattage. Table 5-1 recommends two four-terminal resistors suitable for use as current sampling resistors for the 5V and ±15V outputs. Figure 5-1 shows a four-terminal meter shunt. The load current through a shunt must be fed to the extremes of the wire leading to the resistor while the sampling connections are made as close as possible to the resistance portion itself.

NOTE

Output current limiting would interfere with accurate measurements of the supply's performance. Avoid current limiting by making certain that the current limit adjustments are set sufficiently above the rated output current.

5-11 Rated Output Checks

5-12 To check that the supply will furnish its rated output voltage(s) and current(s), proceed as follows.

a. Connect in series across the (+) and (—) terminals of the 5V output a suitable load resistor, a current sampling resistor, and a switch, as shown in Figure 5-2. The load resistor must be of the proper value and of adequate wattage to draw full rated current from the 5V output.

b. Connect a digital voltmeter across the (+SEN) and (—SEN) terminals of the 5V output, observing correct polarity.

c. Apply input power to the supply and, with the load switch open, set the voltage of the 5V output to any desired value within the adjustment range. This output voltage can be used for all remaining 5V performance tests.

d. Connect the voltmeter across the current sampling terminals of the current sampling resistor, close the load switch, and adjust R_L until the voltmeter indicates a voltage drop corresponding to the 5V output's maximum rated current.

e. Reconnect the voltmeter across the (+SEN) and (—SEN) terminals of the 5V output and recheck its output voltage. It should be within 0.1% of the value set in step (c).

f. Steps (f) and (g) apply only to the triple-output models. Use the same procedure described in steps (a) through (e) above to check the +11.4 to +15.75V output. Connect a switch, a load resistor of appropriate value, and a current sampling resistor in series between the (+) and the COMMON RETURN terminals and monitor the output voltage across the (+SEN) and RETURN SENSE terminals.

g. Check the —11.4 to —15.75V output by using the procedure described in steps (a) through (e) above. Load the COMMON RETURN and (—) terminals and monitor the output voltage across the RETURN SENSE and (—SEN) terminals. Do not readjust the output voltage; the voltage of the negative supply should be within 2% of the positive supply's voltage.

5-13 Input Overvoltage Protection Checks (Models 61005C and 61315D Only)

5-14 Check the input overvoltage protection circuit in the dc-input models as follows:

a. Connect a dc voltmeter across the 5V output of the 61000-Series supply under test. (Leave the supply's output unloaded.)

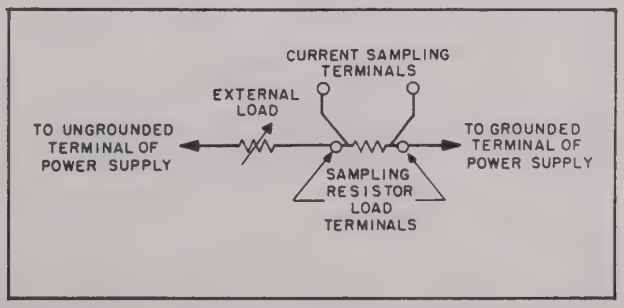

CURRENT SAMPLING TERMINALS
EXTERNAL LOAD
TO UNGROUNDED TERMINAL OF POWER SUPPLY
TO GROUNDED TERMINAL OF POWER SUPPLY
SAMPLING RESISTOR LOAD TERMINALS

Figure 5-1. Current Sampling Resistor Connections

b. Connect another dc voltmeter across the output of a variable dc supply with a 6A load capacity and an output adjustment range of 40Vdc to 70Vdc.

c. Set the variable dc supply's output to about 42 volts, turn this supply off, and connect its output to the input of the supply under test. (Observe correct polarity.)

d. Turn on the variable supply and increase its output voltage gradually while monitoring the voltage at the 5V output of the supply under test. The voltage at the supply's 5V output should fall to zero when its dc input voltage reaches about 63 or 64 volts.

NOTE

If the supply's input voltage reaches 66 volts before its 5V output falls to zero, do not increase the input voltage any further. Instead troubleshoot the malfunction of the input overvoltage comparator on the A1 board. (See Table 5-2.)

e. Now decrease the dc input voltage to the supply under test. The voltage at the supply's 5V output should return to normal before its input voltage reaches 59 volts.

5-15 Current Limit Checks

5-16 To check the operation of the current limit circuit(s), follow the procedure given in steps (f) and (g) of paragraph 3-2.

5-17 Output Overvoltage Protection Checks

5-18 To check the operation of the supply's output overvoltage crowbar circuit(s), follow the procedure given in steps (h), (i), and (j) of paragraph 3-2.

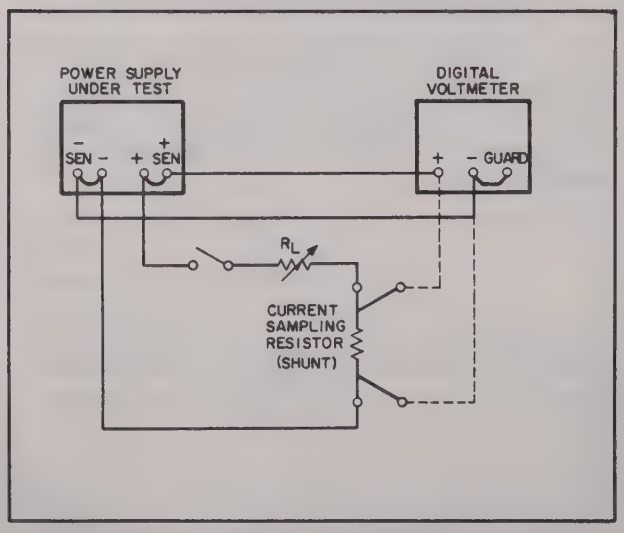


Figure 5-2. Rated Output, Test Setup

5-19 Load Effect (Load Regulation)

Definition: The change ΔE_{OUT} in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice-versa).

5-20 To test the load effect:

a. Connect a full load resistance and a digital voltmeter across the (+) and (—) terminals of the 5V output, as shown in Figure 5-2.

b. Turn on the supply and record the voltage across the 5V output's sensing terminals.

c. Disconnect the load resistor and recheck the DVM indication. It should be within 0.1% of the reading in step (b).

d. Repeat steps (a) through (c) for each of the remaining supply outputs.

5-21 Source Effect (Line Regulation)

Definition: The change ΔE_{OUT}, in the static value of dc output voltage resulting from a change in input voltage over the specified range from low line to high line or from high line to low line.

5-22 To test the source effect:

a. (DC-input models). Connect the input of the supply under test to a source of dc voltage that can be adjusted from 42 to 56 volts.

(AC-input models). Connect a variable autotransformer between the input power source and the power supply's ac input.

b. Connect a full load resistance and a digital voltmeter across the 5V output of the supply.

c. Adjust the power supply's input voltage to the low end of its operating range (42Vdc or 87Vac).

d. Turn on the power and record the DVM indication.

e. Adjust the power supply's input voltage to the high end of its operating range (56Vdc or 127Vac), and recheck the DVM indication. It should be within .02% of the reading in step (d).

f. Repeat steps (b) through (e) for each of the remaining supply outputs.

5-23 PARD (Ripple and Noise)

Definition: The residual ac voltage that is superimposed on the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its rms or peak-to-peak value.

5-24 Measurement Techniques. Figure 5-3A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output

terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply and can completely invalidate the measurement.

5-25 Figure 5-3B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply output. To ensure that no potential difference exists between the supply and the oscilloscope, it is recommended that they both be plugged into the same ac power bus. If the same bus cannot be used, both ac grounds must be at earth ground potential.

5-26 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (–) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-27 Measurement Procedure. To measure the ripple and noise on each supply output, follow the steps below. If a high frequency noise measurement is desired, an oscilloscope with sufficient bandwidth (20MHz) must be used. Ripple and noise measurements can be made at any input ac line voltage combined with any dc output voltage and load current within rating.

a. Connect an oscilloscope or rms voltmeter across an output of the supply as shown in Figure 5-3B.

b. Energize the supply and observe the oscilloscope or meter indication. The ripple and noise should not be greater than 5mV rms or 40mV peak-to-peak.

c. Repeat for the remaining supply outputs.

5-28 Load Transient Recovery Time

Definition: The time it takes for the output voltage to recover to within 1% of the nominal output following a step change in output current from full to half load or vice versa.

5-29 ±11.4 to ±15.75-Volt Outputs. To test the load transient recovery time, a repetitive load switch with a fast switching time is required for loading and unloading the supply. Figure 5-4 shows one way of constructing one using a relay with mercury-wetted contacts. When this load switch is connected to a 60Hz ac input, the mercury relay opens and closes 60 times per second. The 25kΩ control adjusts the duty cycle of the load current switching to reduce jitter in the oscilloscope display. This load switch can also be used with a 50Hz ac input.

5-30 To check the load transient recovery time of each of the ±11.4 to ±15.75V outputs of the Model 61315D or 63315D, proceed as follows:

a. Connect test setup as shown in Figure 5-4. Each load resistor (R_T) is twice the normal full load resistance.

b. Turn on the supply and close the line switch on the repetitive load switch.

c. Adjust the oscilloscope to display the loading and the unloading transients produced by the operation of the load switch. Recovery to within 1% of the nominal output voltage should occur within 25 microseconds as shown in Figure 5-5.

5-31 5-Volt Output. The mercury-wetted relays recommended for use in the repetitive load switch described in Figure 5-4 have a maximum current limitation of 5 amps. For this reason, some other type of repetitive load switch with a higher current capacity is required for testing the

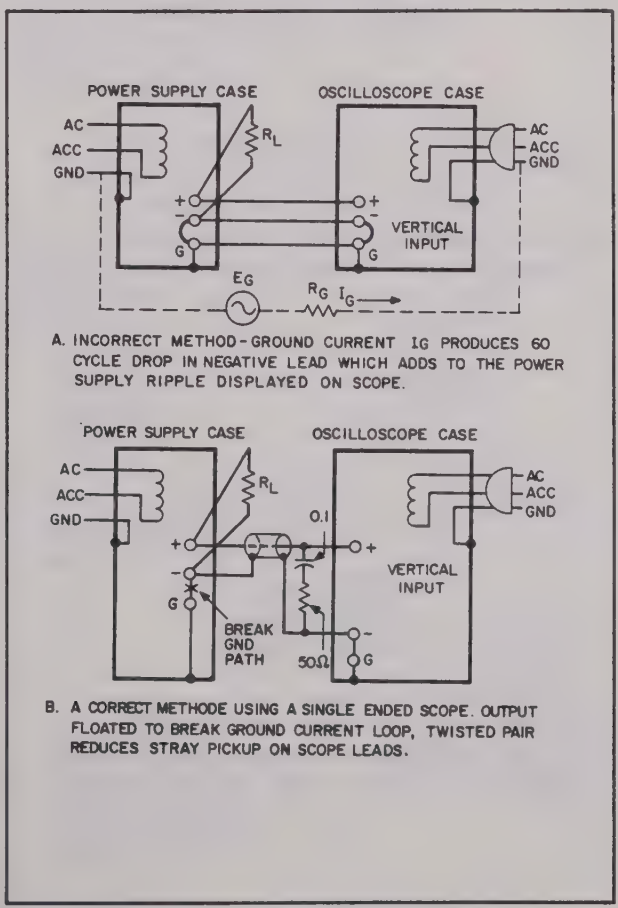

POWER SUPPLY CASE
OSCILLOSCOPE CASE
AC
ACC
GND
R_L
VERTICAL INPUT
E_G
R_G I_G
A. INCORRECT METHOD - GROUND CURRENT IG PRODUCES 60 CYCLE DROP IN NEGATIVE LEAD WHICH ADDS TO THE POWER SUPPLY RIPPLE DISPLAYED ON SCOPE.
0.1
BREAK GND PATH
50Ω
B. A CORRECT METHODE USING A SINGLE ENDED SCOPE. OUTPUT FLOATED TO BREAK GROUND CURRENT LOOP, TWISTED PAIR REDUCES STRAY PICKUP ON SCOPE LEADS.

Figure 5-3. Ripple and Noise, Test Setup

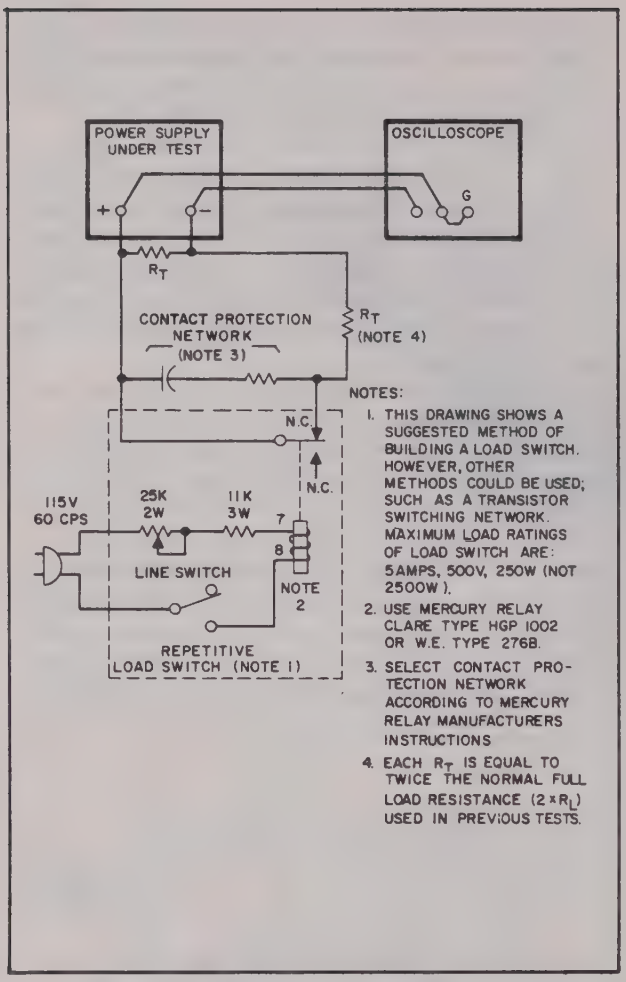

POWER SUPPLY UNDER TEST
OSCILLOSCOPE
+
–
G
R_T
CONTACT PROTECTION NETWORK (NOTE 3)
R_T (NOTE 4)
N.C.
N.C.
115V 60 CPS
25K 2W
11K 3W
7
8
LINE SWITCH
NOTE 2
REPETITIVE LOAD SWITCH (NOTE 1)
NOTES:
1. THIS DRAWING SHOWS A SUGGESTED METHOD OF BUILDING A LOAD SWITCH. HOWEVER, OTHER METHODS COULD BE USED; SUCH AS A TRANSISTOR SWITCHING NETWORK. MAXIMUM LOAD RATINGS OF LOAD SWITCH ARE: 5 AMPS, 500V, 250W (NOT 2500W).
2. USE MERCURY RELAY CLARE TYPE HGP 1002 OR W.E. TYPE 276B.
3. SELECT CONTACT PROTECTION NETWORK ACCORDING TO MERCURY RELAY MANUFACTURERS INSTRUCTIONS
4. EACH R_T IS EQUAL TO TWICE THE NORMAL FULL LOAD RESISTANCE ($2 \times R_L$) USED IN PREVIOUS TESTS.

Figure 5-4. Load Transient Recovery Time, Test Setup

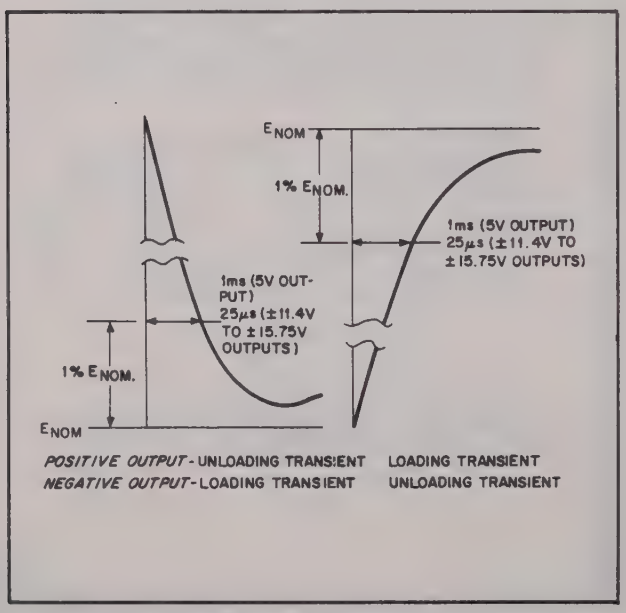


Figure 5-5. Load Transient Recovery Time Waveforms

load transient recovery time of the 5V output. The use of a solid state electrical load with pulse modulation capabilities such as the Transistor Devices Dynaload DLP 50-60-1000 is one way to avoid the rise time and switching noise limitations of mechanical switches at currents above 5 amps.

5-32 To check the load transient recovery time of the 5V output, proceed as follows:

a. Connect test setup as shown in Figure 5-4, but in place of the load switch and contact protection network shown, substitute a solid state repetitive load switch with a current capacity of at least half of the supply's rated output and a rise time of less than 100 microseconds. (Since the supply's recovery time is specified for a change between half and full load, the switch conducts only half of the supply's rated output.) Each load resistor (R_T) is twice the normal full load resistance.

b. Turn on the supply and the load switch.

c. Adjust the oscilloscope to display the loading and the unloading transients produced by the operation of the load switch. Recovery to within 1% of the nominal output voltage should occur within 1 millisecond as shown in Figure 5-5.

5-33 TROUBLESHOOTING

5-34 Before attempting to troubleshoot this instrument, ensure that the fault is in the instrument itself and not in an associated piece of equipment. You can determine this without removing the covers from the instrument by using the appropriate portions of the performance test of paragraph 5-6.

5-35 A good understanding of the principles of operation is a helpful aid in troubleshooting, and the reader is advised to review Section IV of the manual before beginning detailed troubleshooting. Once the principles of operation are understood, proceed to the initial troubleshooting procedures in paragraph 5-36.

5-36 Initial Troubleshooting Procedures

WARNING

In the ac-input models all circuits on the A1 board as well as the primary windings of transformer T2 on the A2 board are connected directly to the input ac line. Exercise extreme caution when working on energized circuits. Also, energize the supply through an isolation transformer with a power rating of at least 750VA to avoid shorting ac line energized circuits to ground through the test instrument's input leads.

CAUTION

Before applying power to the supply, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used.

All loads should be disconnected while troubleshooting. If checks must be made that require loading the supply while the circuit boards are detached from the main heatsink, restrict the time the output is loaded to 15 seconds to avoid overheating.

5-37 If a malfunction occurs that causes an output voltage to be high, low, or zero, proceed to the circuit board isolation procedure of Figure 5-6. This procedure identifies the board on which troubleshooting must begin. The A1 board must be operating properly before troubleshooting of the A2 board can proceed, and both the A1 and A2 boards must be operating properly before troubleshooting the A3 board. Follow all steps in the order in which they are given.

5-38 If the unit's output voltages are normal but difficulties exist with its ripple, noise, or regulation, proceed to Table 5-2.

5-39 REPAIR AND REPLACEMENT

5-40 Disassembly

5-41 Follow the steps below to disassemble the unit for troubleshooting and repair.

a. Before removing the cover, remove the plastic barrier block cover and disconnect all input and output connections.

b. Remove six screws at the bottom edge of the cover and two at the top. Then it can be slid off the supply.

c. Detach the finned heatsink by removing its four screws.

d. Remove the two spacer rods from the top of the circuit boards.

e. Remove one screw from the bottom of the unit that attaches the A3 board to the chassis in the Model 61315D or 63315D.

f. Now, removing the four or six flat-head screws that were exposed by the removal of the heatsink and the three screws along the bottom edge of the A1 board (and the two screws at the corners of the A2 board in a single-output unit) will permit all boards to be detached from the chassis as a single assembly. In the Model 63005C or 63315D, three A4L1 leads and one ground wire still connect the A1 board to the chassis.

g. The A1 board can be detached from the A2/A3 assembly by pulling straight apart to unplug the pins at the top of A2T2 from A1J1.

h. To separate the A2 and A3 boards, remove the two screws at opposite corners.

5-42 Reassembly

5-43 To reassemble the unit after repairs have been completed, reverse the above disassembly steps. Before reassembling the A1 and A2 boards to the main heatsink, clean the mating surfaces and both sides of the sheet of insulating material that goes between them and apply a coating of silicone grease (HP Part No. 6040-0265) or Dow Corning 340) to these surfaces.

5-44 Replacing Power Semiconductors

5-45 Replace heatsink mounted power transistors and diodes by removing their mounting screws and unsoldering their pins. Use mica insulators under A2Q1, A2U2, A3Q1, and A3Q4, but do not use one under A1Q4 or Q5 in 61000-Series supplies or under A1Q5 in 63000-Series supplies. (The mica insulator for A2Q1 is supplied with the replacement device.) When replacing power semiconductors, coat the heat transfer surfaces with silicone grease.

NOTE

When replacing any wirewound power resistors of 3W rating or greater, allow a 1/4-inch clearance between the resistor and the circuit board.

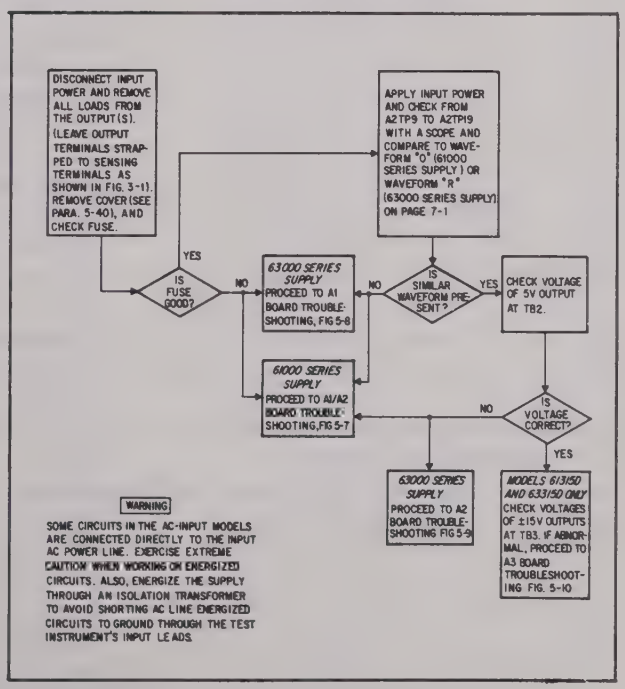

DISCONNECT INPUT POWER AND REMOVE ALL LOADS FROM THE OUTPUT(S). (LEAVE OUTPUT TERMINALS STRAPPED TO SENSING TERMINALS AS SHOWN IN FIG. 3-1). REMOVE COVER (SEE PARA. 5-40), AND CHECK FUSE.
APPLY INPUT POWER AND CHECK FROM A2TP9 TO A2TP19 WITH A SCOPE AND COMPARE TO WAVEFORM "Q" (61000 SERIES SUPPLY) OR WAVEFORM "R" (63000 SERIES SUPPLY) ON PAGE 7-1
IS FUSE GOOD?
YES
NO
63000 SERIES SUPPLY PROCEED TO A1 BOARD TROUBLESHOOTING, FIG 5-8
IS SIMILAR WAVEFORM PRESENT?
NO
YES
CHECK VOLTAGE OF 5V OUTPUT AT TB2.
60000 SERIES SUPPLY PROCEED TO A1/A2 BOARD TROUBLESHOOTING, FIG 5-7
IS VOLTAGE CORRECT?
NO
YES
63000 SERIES SUPPLY PROCEED TO A2 BOARD TROUBLESHOOTING FIG 5-9
MODELS 61315D AND 63315D ONLY CHECK VOLTAGES OF ±15V OUTPUTS AT TB3. IF ABNORMAL, PROCEED TO A3 BOARD TROUBLESHOOTING FIG. 5-10
WARNING
SOME CIRCUITS IN THE AC-INPUT MODELS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.

Figure 5-6. Circuit Board Isolation Procedure

5-46 ADJUSTMENTS

NOTE

Before adjusting an output current limit, the voltage of that output must be set to the desired value.

5-47 To adjust the setting of one of the output current limit circuits, proceed as follows:

a. Before energizing the supply, connect across the output an oscilloscope and a load resistor equal in value to the desired output voltage divided by the desired current limit. (For example, to set the current limit of the 5V output to 20 amps when the output is set for 5.20 volts, a 260-milliohm 100-watt load resistor is required.)

b. Turn the current limit adjusting pot for the output being adjusted fully clockwise (CW) to its maximum setting.

c. Energize the supply and monitor the output ripple while turning the current limit adjusting pot gradually counterclockwise (CCW) until the ripple begins to increase substantially. Set the pot to the point where the increase in ripple begins.

Table 5-2. Miscellaneous Troubleshooting

Symptom	Probable Cause
Excessive 120Hz ripple (ac-input models).	Check voltage and ripple at preregulator output (A2TP1 to TP2). Voltage should be +100 ±6Vdc. Ripple should not exceed 12V p-p with the supply fully loaded. Check A1C2-C7.
Excessive 20kHz ripple or noise spikes.	Check all board mounting screws tightened securely and the following components. 5V Output: Check A2C3, C5, C12, C16-19, L1, L3. ±15V Outputs: Check A3C1, C2, C8-C11, C16-18, C20, C21, L1, L2, L5, L6.
Erratic output at some value of load current.	Check A2CR3, C4, R7, R8, R11.
Poor regulation.	a. Check remote sensing connections. b. Check the settings of current limit controls A2R34, A3R9, and A3R23. c. (Ac-input models). Check change in preregulator dc output (A1TP1 to TP12) as the supply is loaded. Troubleshoot preregulator if voltage change exceeds 6Vdc. d. Check bias voltages: A2TP1 to TP2 (+12 to +16Vdc), A2TP1 to TP3 (+8 to +10Vdc). e. Check reference voltages: A2TP13 to TP20 (+6.8 to +7.5Vdc), and COMMON RETURN on TB3 to A3TP20 (+6.8 to +7.5Vdc). f. Check regulator IC's (A2U4, A3U1, A3U2) and pulse width modulator (A2U1).
Input overvoltage protection does not operate (dc-input models).	Check Q1, CR2, U1, VR1.

Table 5-3. Switching Regulator Resistance Checks (Models 63305C and 63315D)

All resistance readings taken on A1 board with A2 board disconnected. One silicon junction drop equals about 0.7 volts dc.

Negative Lead	Positive Lead	Normal Indication	Probable Cause of Abnormal Indication
Q8 emitter (TP8)	Q5 base	47Ω	Q5 shorted
	Q5 collector	open	Q5 shorted
	U3 pin 4	one drop + 165Ω	U3 shorted, Q7 open
	Q8 collector	one drop + 600Ω	Q8 shorted
	Q8 base	two drops	CR16-17, Q8 shorted
	Q10 base	> 5kΩ	Q9, Q10 shorted
	CR21 anode	one drop	CR21 defective
	Q10 collector	> 5kΩ	Q10, CR19 shorted
Q7 emitter	CR20 cathode	open	CR20 shorted
	Q7 collector	440Ω	Q6, Q7 shorted
Q10 collector	CR19 anode	one drop	CR19 shorted
▽1 (TP1)	VR3 anode	two drops	VR3 or VR4 defective
U3 pin 2 (Note 1)	U3 pin 1	two drops	U3 defective
CR13 cathode	CR13 anode	three drops (Note 2)	CR13 defective
CR14 cathode	CR15 anode	two drops	CR14 or CR15 defective
	CR11 anode	one drop	CR11 defective
CR12 cathode	CR12 anode	one drop	CR12 defective
Q5 collector	CR14 cathode	one drop	CR22 defective
	CR18 anode	one drop	CR18 defective
	Q5 base	one drop	Q5 open
CR20 cathode	CR20 anode	one drop	CR20 defective
Q6 base	Q6 collector	one drop	Q6 open
	Q6 emitter	one drop	Q6 open
Q7 emitter	Q7 base	one drop	Q7 open
Q7 collector	Q7 base	one drop	Q7 open
Q8 base	Q8 emitter	one drop	Q8 open
	Q8 collector	one drop	Q8 open
Q9 base	Q9 emitter	one drop	Q9 open
	Q10 emitter	one drop	Q10 open
	Q10 collector	one drop	Q10 open
U3 pin 5	U3 pin 6	one drop	U3 open
U3 pin 4	U3 pin 6	one drop	U3 open

Notes: 1. Not a silicon junction. Do not apply more than 7 volts in testing.
2. May appear open on low ohmmeter range. Requires minimum of 3 volts to test.

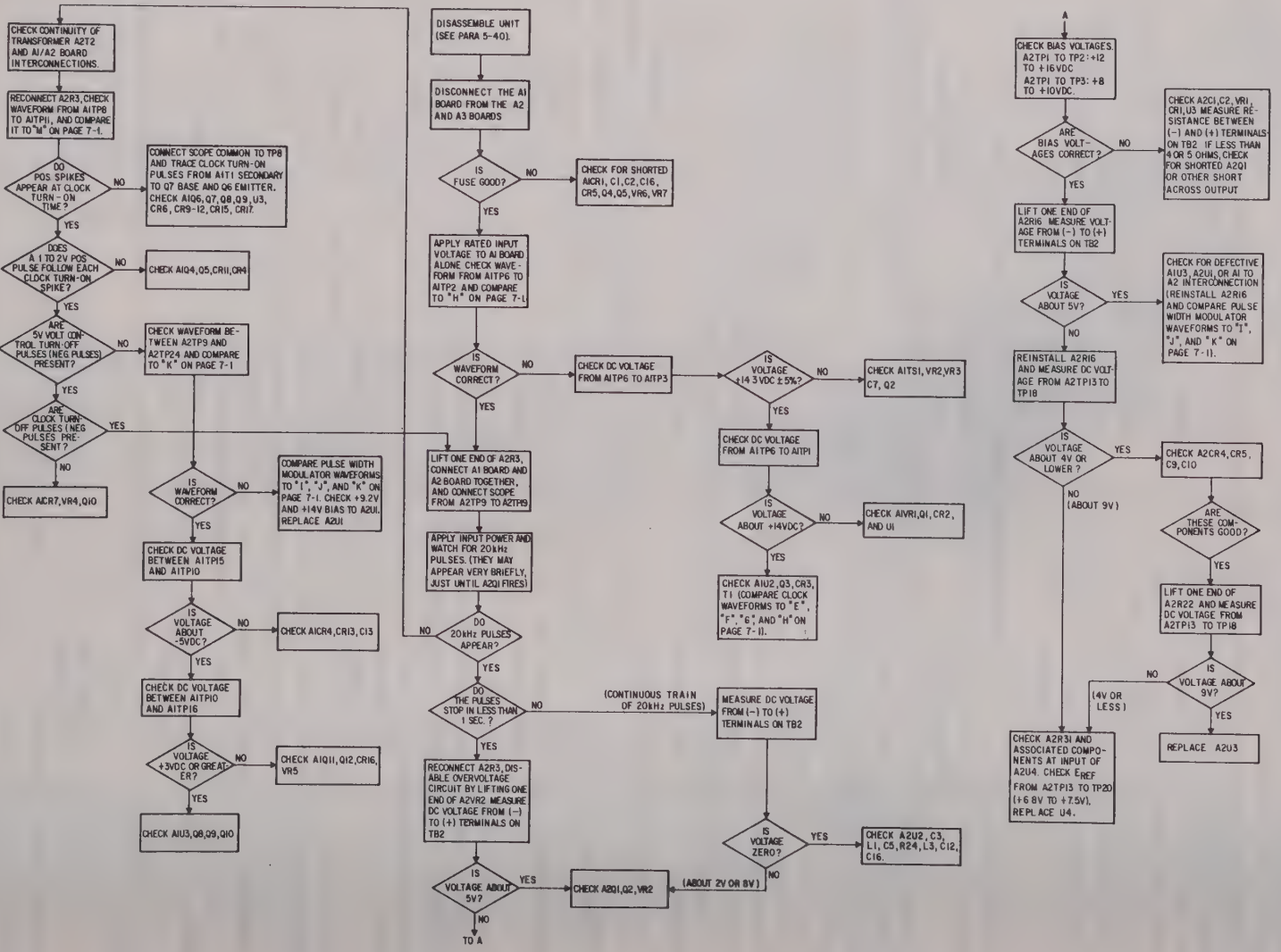

A1 AND A2 BOARD TROUBLESHOOTING (MODELS 61005C AND 61315D)
CHECK CONTINUITY OF TRANSFORMER A2T2 AND A1/A2 BOARD INTERCONNECTIONS.
RECONNECT A2R3, CHECK WAVEFORM FROM A1TP8 TO A1TP11, AND COMPARE IT TO "H" ON PAGE 7-1.
DO POS. SPIKES APPEAR AT CLOCK TURN-ON TIME?
NO
CONNECT SCOPE COMMON TO TP8 AND TRACE CLOCK TURN-ON PULSES FROM A1T1 SECONDARY TO Q7 BASE AND Q6 EMITTER. CHECK A1Q6, Q7, Q8, Q9, U3, CR6, CR9-12, CR15, CR17.
YES
DOES A 1 TO 2V POS PULSE FOLLOW EACH CLOCK TURN-ON SPIKE?
NO
CHECK A1Q4, Q5, CR11, CR4
YES
ARE 5V VOLT CONTROL TURN-OFF PULSES (NEG PULSES) PRESENT?
NO
CHECK WAVEFORM BETWEEN A2TP3 AND A2TP24 AND COMPARE TO "K" ON PAGE 7-1
YES
ARE CLOCK TURN-OFF PULSES (NEG PULSES) PRESENT?
YES
NO
CHECK A1CR7, VR4, Q10
IS WAVEFORM CORRECT?
NO
COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I", "J", AND "K" ON PAGE 7-1. CHECK +9.2V AND +14V BIAS TO A2U1. REPLACE A2U1
YES
CHECK DC VOLTAGE BETWEEN A1TP15 AND A1TP10
IS VOLTAGE ABOUT -5VDC?
NO
CHECK A1CR4, CR13, C13
YES
CHECK DC VOLTAGE BETWEEN A1TP10 AND A1TP16
IS VOLTAGE +3VDC OR GREATER?
NO
CHECK A1Q11, Q12, CR16, VR5
YES
CHECK A1U3, Q8, Q9, Q10
DISASSEMBLE UNIT (SEE PARA 5-40).
DISCONNECT THE A1 BOARD FROM THE A2 AND A3 BOARDS
IS FUSE GOOD?
NO
CHECK FOR SHORTED A1CR1, C1, C2, C16, CR5, Q4, Q5, VR6, VR7
YES
APPLY RATED INPUT VOLTAGE TO A1 BOARD ALONE. CHECK WAVEFORM FROM A1TP6 TO A1TP2 AND COMPARE TO "H" ON PAGE 7-1.
IS WAVEFORM CORRECT?
NO
CHECK DC VOLTAGE FROM A1TP6 TO A1TP3
IS VOLTAGE +14.3VDC ±5%?
NO
CHECK A1T1, VR2, VR3 C7, Q2
YES
CHECK DC VOLTAGE FROM A1TP6 TO A1TP1
IS VOLTAGE ABOUT +14VDC?
NO
CHECK A1VR1, Q1, CR2, AND U1
YES
CHECK A1U2, Q3, CR3, T1 (COMPARE CLOCK WAVEFORMS TO "E", "F", "G", AND "H" ON PAGE 7-1).
YES
LIFT ONE END OF A2R3, CONNECT A1 BOARD AND A2 BOARD TOGETHER, AND CONNECT SCOPE FROM A2TP9 TO A2TP19
APPLY INPUT POWER AND WATCH FOR 20kHz PULSES. (THEY MAY APPEAR VERY BRIEFLY, JUST UNTIL A2Q1 FIRES)
DO 20kHz PULSES APPEAR?
NO
YES
DO THE PULSES STOP IN LESS THAN 1 SEC.?
NO
(CONTINUOUS TRAIN OF 20kHz PULSES)
MEASURE DC VOLTAGE FROM (-) TO (+) TERMINALS ON TB2
YES
RECONNECT A2R3, DISABLE OVERVOLTAGE CIRCUIT BY LIFTING ONE END OF A2VR2. MEASURE DC VOLTAGE FROM (-) TO (+) TERMINALS ON TB2
IS VOLTAGE ZERO?
YES
CHECK A2U2, C3, L1, C5, R24, L3, C12, C16.
NO
(ABOUT 2V OR 8V)
IS VOLTAGE ABOUT 5V?
YES
CHECK A2Q1, Q2, VR2
NO
TO A
A
CHECK BIAS VOLTAGES. A2TP1 TO TP2: +12 TO +16VDC A2TP1 TO TP3: +8 TO +10VDC.
ARE BIAS VOLTAGES CORRECT?
NO
CHECK A2C1, C2, VR1, CR1, U3 MEASURE RESISTANCE BETWEEN (-) AND (+) TERMINALS ON TB2. IF LESS THAN 4 OR 5 OHMS, CHECK FOR SHORTED A2Q1 OR OTHER SHORT ACROSS OUTPUT
YES
LIFT ONE END OF A2R16. MEASURE VOLTAGE FROM (-) TO (+) TERMINALS ON TB2
IS VOLTAGE ABOUT 5V?
YES
CHECK FOR DEFECTIVE A1U3, A2U1, OR A1 TO A2 INTERCONNECTION (REINSTALL A2R16 AND COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I", "J", AND "K" ON PAGE 7-1).
NO
REINSTALL A2R16 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 4V OR LOWER?
YES
CHECK A2CR4, CR5, C9, C10
ARE THESE COMPONENTS GOOD?
YES
LIFT ONE END OF A2R22 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 9V?
NO
(4V OR LESS)
YES
REPLACE A2U3
NO (ABOUT 9V)
CHECK A2R31 AND ASSOCIATED COMPONENTS AT INPUT OF A2U4. CHECK EREF FROM A2TP13 TO TP20 (+6.8V TO +7.5V). REPLACE U4.

Figure 5-7. A1/A2 Board Troubleshooting Procedure, 61000-Series Supplies

A1 BOARD TROUBLESHOOTING (MODELS 63005C AND 63315D)

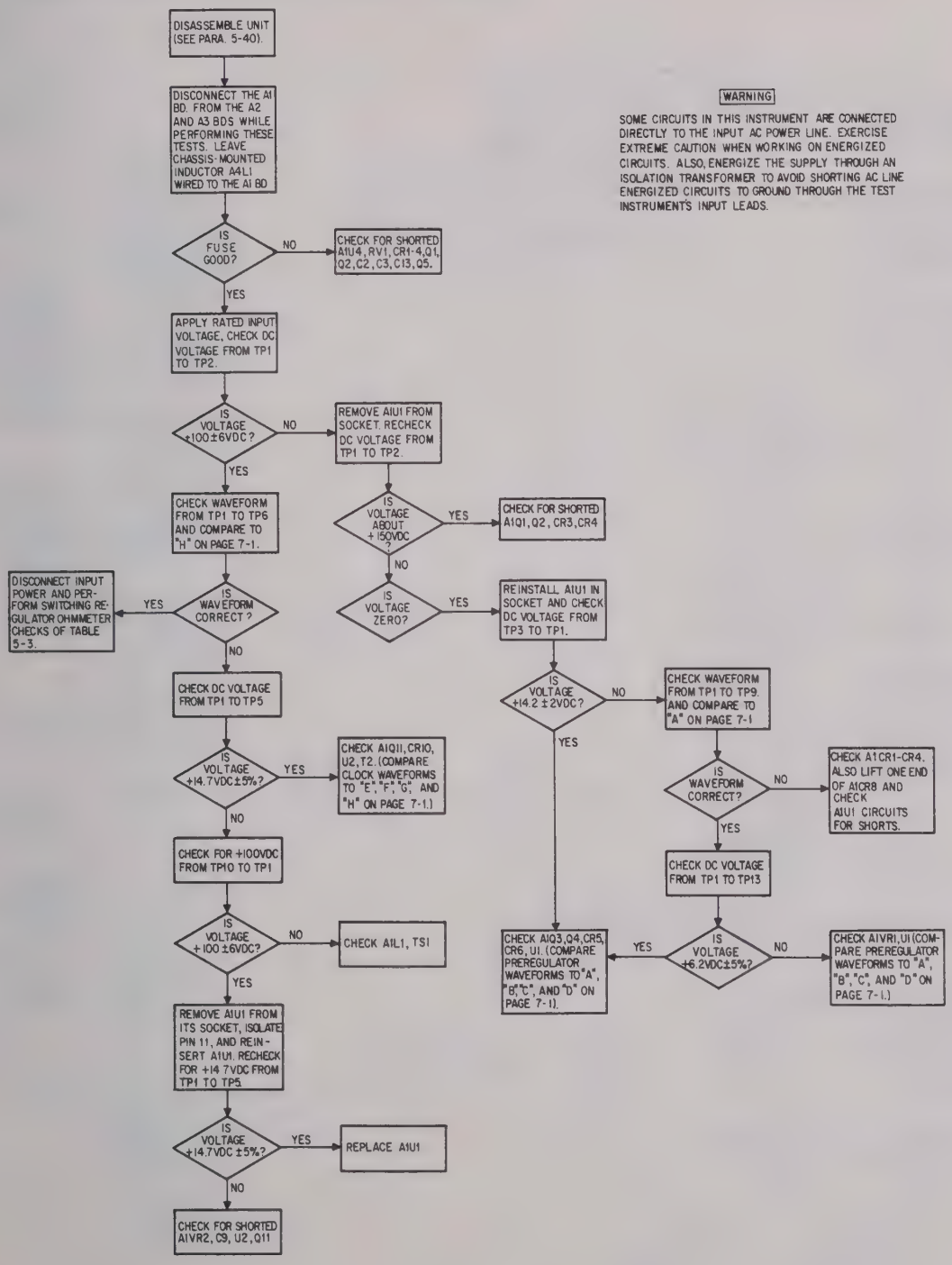

DISASSEMBLE UNIT (SEE PARA. 5-40).
DISCONNECT THE A1 BD. FROM THE A2 AND A3 BDS WHILE PERFORMING THESE TESTS. LEAVE CHASSIS-MOUNTED INDUCTOR A4L1 WIRED TO THE A1 BD
IS FUSE GOOD?
NO
CHECK FOR SHORTED A1U4, RV1, CR1-4, Q1, Q2, C2, C3, C13, Q5.
YES
APPLY RATED INPUT VOLTAGE, CHECK DC VOLTAGE FROM TP1 TO TP2.
IS VOLTAGE +100±6VDC?
NO
REMOVE A1U1 FROM SOCKET. RECHECK DC VOLTAGE FROM TP1 TO TP2.
YES
CHECK WAVEFORM FROM TP1 TO TP6 AND COMPARE TO "H" ON PAGE 7-1.
IS VOLTAGE ABOUT +150VDC?
YES
CHECK FOR SHORTED A1Q1, Q2, CR3, CR4
NO
IS VOLTAGE ZERO?
YES
REINSTALL A1U1 IN SOCKET AND CHECK DC VOLTAGE FROM TP3 TO TP1.
IS WAVEFORM CORRECT?
YES
DISCONNECT INPUT POWER AND PERFORM SWITCHING REGULATOR OHMMETER CHECKS OF TABLE 5-3.
NO
CHECK DC VOLTAGE FROM TP1 TO TP5
IS VOLTAGE +14.7VDC±5%?
YES
CHECK A1Q11, CR10, U2, T2. (COMPARE CLOCK WAVEFORMS TO "E", "F", "G", AND "H" ON PAGE 7-1.)
NO
CHECK FOR +100VDC FROM TP10 TO TP1
IS VOLTAGE +100±6VDC?
NO
CHECK A1L1, TS1
YES
REMOVE A1U1 FROM ITS SOCKET, ISOLATE PIN 11, AND REINSERT A1U1. RECHECK FOR +14.7VDC FROM TP1 TO TP5.
IS VOLTAGE +14.7VDC±5%?
YES
REPLACE A1U1
NO
CHECK FOR SHORTED A1VR2, C9, U2, Q11
IS VOLTAGE +14.2±2VDC?
NO
CHECK WAVEFORM FROM TP1 TO TP9. AND COMPARE TO "A" ON PAGE 7-1
YES
IS WAVEFORM CORRECT?
NO
CHECK A1CR1-CR4. ALSO LIFT ONE END OF A1CR8 AND CHECK A1U1 CIRCUITS FOR SHORTS.
YES
CHECK DC VOLTAGE FROM TP1 TO TP13
IS VOLTAGE +6.2VDC±5%?
YES
CHECK A1Q3, Q4, CR5, CR6, U1. (COMPARE PREREGULATOR WAVEFORMS TO "A", "B", "C", AND "D" ON PAGE 7-1).
NO
CHECK A1VR1, U1 (COMPARE PREREGULATOR WAVEFORMS TO "A", "B", "C", AND "D" ON PAGE 7-1.)
WARNING
SOME CIRCUITS IN THIS INSTRUMENT ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.

Figure 5-8. A1 Board Troubleshooting Procedure, 63000-Series Supplies

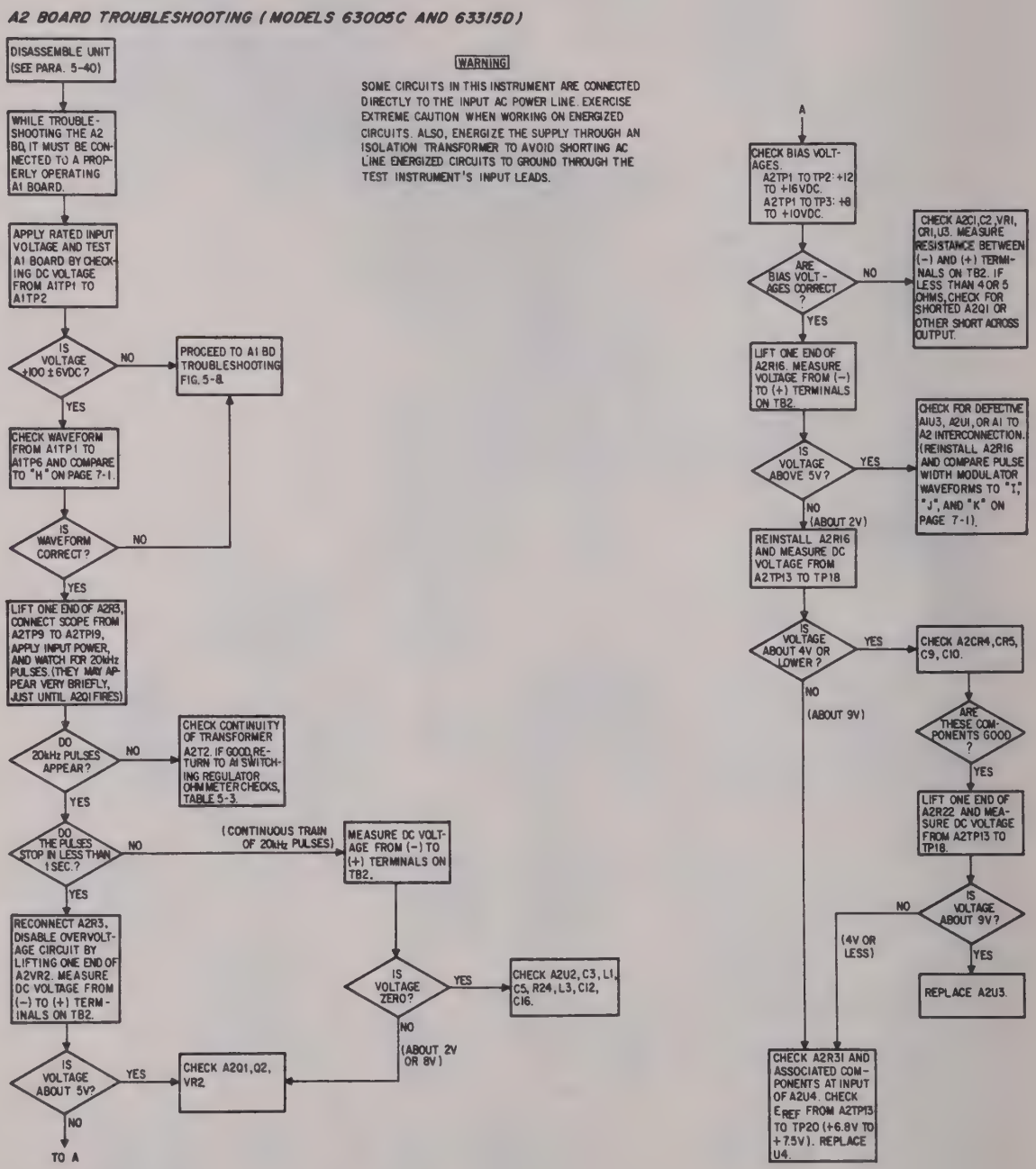

A2 BOARD TROUBLESHOOTING (MODELS 63005C AND 63315D)
DISASSEMBLE UNIT (SEE PARA. 5-40)
WHILE TROUBLE-SHOOTING THE A2 BD, IT MUST BE CONNECTED TO A PROPERLY OPERATING A1 BOARD.
APPLY RATED INPUT VOLTAGE AND TEST A1 BOARD BY CHECKING DC VOLTAGE FROM A1TP1 TO A1TP2
IS VOLTAGE +100 ±6VDC?
NO
PROCEED TO A1 BD TROUBLESHOOTING FIG. 5-8.
YES
CHECK WAVEFORM FROM A1TP1 TO A1TP6 AND COMPARE TO "H" ON PAGE 7-1.
IS WAVEFORM CORRECT?
NO
YES
LIFT ONE END OF A2R3, CONNECT SCOPE FROM A2TP9 TO A2TP19, APPLY INPUT POWER, AND WATCH FOR 20kHz PULSES. (THEY MAY APPEAR VERY BRIEFLY, JUST UNTIL A2Q1 FIRES)
DO 20kHz PULSES APPEAR?
NO
CHECK CONTINUITY OF TRANSFORMER A2T2. IF GOOD, RETURN TO A1 SWITCHING REGULATOR OHMMETER CHECKS, TABLE 5-3.
YES
DO THE PULSES STOP IN LESS THAN 1 SEC.?
NO
(CONTINUOUS TRAIN OF 20kHz PULSES)
MEASURE DC VOLTAGE FROM (-) TO (+) TERMINALS ON T82.
YES
RECONNECT A2R3. DISABLE OVERVOLTAGE CIRCUIT BY LIFTING ONE END OF A2VR2. MEASURE DC VOLTAGE FROM (-) TO (+) TERMINALS ON TB2.
IS VOLTAGE ZERO?
YES
CHECK A2U2, C3, L1, C5, R24, L3, C12, C16.
NO
(ABOUT 2V OR 8V)
IS VOLTAGE ABOUT 5V?
YES
CHECK A2Q1, Q2, VR2
NO
TO A
WARNING
SOME CIRCUITS IN THIS INSTRUMENT ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.
A
CHECK BIAS VOLTAGES. A2TP1 TO TP2: +12 TO +16VDC. A2TP1 TO TP3: +8 TO +10VDC.
ARE BIAS VOLTAGES CORRECT?
NO
CHECK A2C1, C2, VR1, CR1, U3. MEASURE RESISTANCE BETWEEN (-) AND (+) TERMINALS ON TB2. IF LESS THAN 4 OR 5 OHMS, CHECK FOR SHORTED A2Q1 OR OTHER SHORT ACROSS OUTPUT.
YES
LIFT ONE END OF A2R16. MEASURE VOLTAGE FROM (-) TO (+) TERMINALS ON TB2.
IS VOLTAGE ABOVE 5V?
YES
CHECK FOR DEFECTIVE A1U3, A2U1, OR A1 TO A2 INTERCONNECTION. (REINSTALL A2R16 AND COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I," "J", AND "K" ON PAGE 7-11).
NO
(ABOUT 2V)
REINSTALL A2R16 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 4V OR LOWER?
YES
CHECK A2CR4, CR5, C9, C10.
NO
(ABOUT 9V)
ARE THESE COMPONENTS GOOD?
YES
LIFT ONE END OF A2R22 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18.
IS VOLTAGE ABOUT 9V?
NO
(4V OR LESS)
YES
REPLACE A2U3.
CHECK A2R31 AND ASSOCIATED COMPONENTS AT INPUT OF A2U4. CHECK E_{REF} FROM A2TP13 TO TP20 (+6.8V TO +7.5V). REPLACE U4.

Figure 5-9. A2 Board Troubleshooting, 63000-Series Supplies

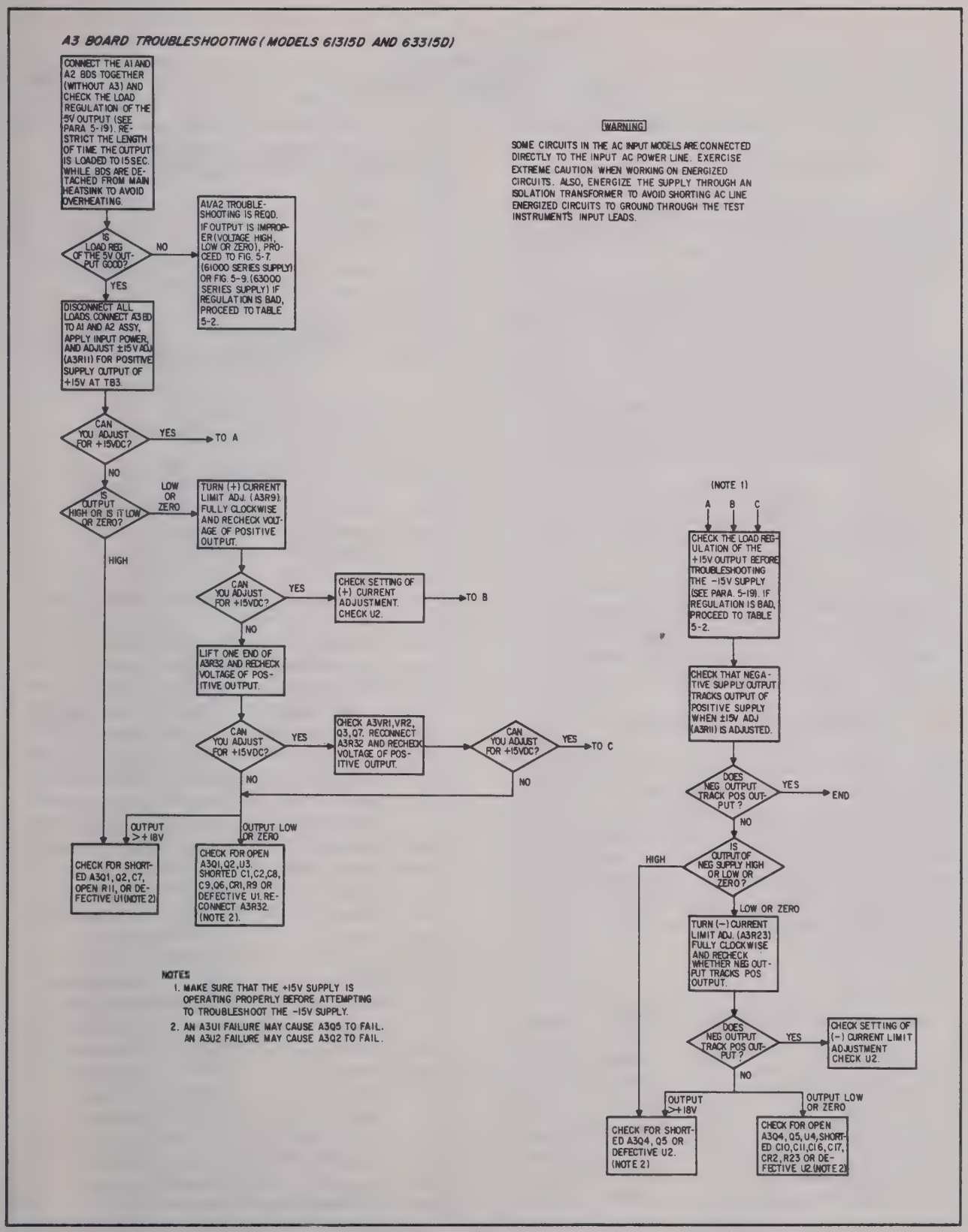

A3 BOARD TROUBLESHOOTING (MODELS 61315D AND 63315D)
CONNECT THE A1 AND A2 BDS TOGETHER (WITHOUT A3) AND CHECK THE LOAD REGULATION OF THE 5V OUTPUT (SEE PARA 5-19). RESTRICT THE LENGTH OF TIME THE OUTPUT IS LOADED TO 15 SEC. WHILE BDS ARE DETACHED FROM MAIN HEATSINK TO AVOID OVERHEATING.
IS LOAD REG OF THE 5V OUTPUT GOOD?
NO
A1/A2 TROUBLESHOOTING IS REQD. IF OUTPUT IS IMPROPER (VOLTAGE HIGH, LOW OR ZERO), PROCEED TO FIG. 5-7. (61000 SERIES SUPPLY) OR FIG. 5-9. (63000 SERIES SUPPLY) IF REGULATION IS BAD, PROCEED TO TABLE 5-2.
YES
DISCONNECT ALL LOADS. CONNECT A3 ED TO A1 AND A2 ASSY, APPLY INPUT POWER, AND ADJUST ±15V ADJ (A3R11) FOR POSITIVE SUPPLY OUTPUT OF +15V AT TB3.
CAN YOU ADJUST FOR +15VDC?
YES
TO A
NO
IS OUTPUT HIGH OR IS IT LOW OR ZERO?
LOW OR ZERO
TURN (+) CURRENT LIMIT ADJ. (A3R9) FULLY CLOCKWISE AND RECHECK VOLTAGE OF POSITIVE OUTPUT.
HIGH
CAN YOU ADJUST FOR +15VDC?
YES
CHECK SETTING OF (+) CURRENT ADJUSTMENT. CHECK U2.
TO B
NO
LIFT ONE END OF A3R32 AND RECHECK VOLTAGE OF POSITIVE OUTPUT.
CAN YOU ADJUST FOR +15VDC?
YES
CHECK A3VR1, VR2, Q3, Q7. RECONNECT A3R32 AND RECHECK VOLTAGE OF POSITIVE OUTPUT.
CAN YOU ADJUST FOR +15VDC?
YES
TO C
NO
NO
OUTPUT >+18V
OUTPUT LOW OR ZERO
CHECK FOR SHORTED A3Q1, Q2, C7, OPEN R11, OR DEFECTIVE U1 (NOTE 2)
CHECK FOR OPEN A3Q1, Q2, U3. SHORTED C1, C2, C8, C9, Q6, CR1, R9 OR DEFECTIVE U1. RECONNECT A3R32. (NOTE 2).
WARNING
SOME CIRCUITS IN THE AC INPUT MODELS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.
(NOTE 1)
A B C
CHECK THE LOAD REGULATION OF THE +15V OUTPUT BEFORE TROUBLESHOOTING THE -15V SUPPLY (SEE PARA. 5-19). IF REGULATION IS BAD, PROCEED TO TABLE 5-2.
CHECK THAT NEGATIVE SUPPLY OUTPUT TRACKS OUTPUT OF POSITIVE SUPPLY WHEN ±15V ADJ (A3R11) IS ADJUSTED.
DOES NEG OUTPUT TRACK POS OUTPUT?
YES
END
NO
IS OUTPUT OF NEG SUPPLY HIGH OR LOW OR ZERO?
HIGH
LOW OR ZERO
TURN (-) CURRENT LIMIT ADJ. (A3R23) FULLY CLOCKWISE AND RECHECK WHETHER NEG OUTPUT TRACKS POS OUTPUT.
DOES NEG OUTPUT TRACK POS OUTPUT?
YES
CHECK SETTING OF (-) CURRENT LIMIT ADJUSTMENT CHECK U2.
NO
OUTPUT >+18V
OUTPUT LOW OR ZERO
CHECK FOR SHORTED A3Q4, Q5 OR DEFECTIVE U2. (NOTE 2)
CHECK FOR OPEN A3Q4, Q5, U4, SHORTED C10, C11, C16, C17, CR2, R23 OR DEFECTIVE U2. (NOTE 2)
NOTES:
1. MAKE SURE THAT THE +15V SUPPLY IS OPERATING PROPERLY BEFORE ATTEMPTING TO TROUBLESHOOT THE -15V SUPPLY.
2. AN A3U1 FAILURE MAY CAUSE A3Q5 TO FAIL. AN A3U2 FAILURE MAY CAUSE A3Q2 TO FAIL.

Figure 5-10. A3 Board Troubleshooting Procedure

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-3 lists parts in alpha-numeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-3 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-3, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor		
R	= resistor		
S	= switch	VR	= zener diode
T	= transformer	X	= socket
TB	= terminal block	Z	= integrated circuit or network
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mod.	= modular or modified
ac	= alternating current	mtg	= mounting
assy.	= assembly	n	= nano = 10^{-9}
bd	= board	NC	= normally closed
bkt	= bracket	NO	= normally open
°C	= degree Centigrade	NP	= nickel-plated
cd	= card	Ω	= ohm
coef	= coefficient	obd	= order by description
comp	= composition	OD	= outside diameter
CRT	= cathode-ray tube	p	= pico = 10^{-12}
CT	= center-tapped	P.C.	= printed circuit
dc	= direct current	pot.	= potentiometer
DPDT	= double pole, double throw	p-p	= peak-to-peak
DPST	= double pole, single throw	ppm	= parts per million
elect	= electrolytic	pvr	= peak reverse voltage
encap	= encapsulated	rect	= rectifier
F	= farad	rms	= root mean square
°F	= degree Farenheit	Si	= silicon
fxd	= fixed	SPDT	= single pole, double throw
Ge	= germanium	SPST	= single pole, single throw
H	= Henry	SS	= small signal
Hz	= Hertz	T	= slow-blow
IC	= integrated circuit	tan.	= tantulum
ID	= inside diameter	Ti	= titanium
incnd	= incandescent	V	= volt
k	= kilo = 10^{3}	var	= variable
m	= milli = 10^{-3}	ww	= wirewound
M	= mega = 10^{6}	W	= Watt
μ	= micro = 10^{-6}		
met.	= metal		
mfr	= manufacturer		

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	A1 DC-DC Converter (Note 1) (Models 61005C and 61315D Only)					
C1, 2	fxd, elect. 500μF 150V	2	(Type 68D) D40701	56289	0180-1889	1
C3	fxd, cer. .05μF 400V	1	33C17A3-CDH	56289	0150-0052	1
C4	fxd, mica 30pF 500V	1	obd	72136	0140-0203	1
C5	fxd, elect. 10μF 20V	3	150D106X9020B2	56289	0180-0374	1
C6	fxd, cer. 1000pF 1kV	1	C067B102E102ZS26	56289	0150-0050	1
C7	fxd, elect. 10μF 20V		150D106X9020B2	56289	0180-0374	
C8	fxd, mica 2000pF 100V	1	obd	72136	0160-2301	1
C9	fxd, cer. .01μF 100V	1	TA	91418	0150-0093	1
C10	fxd, polyester .068μF 200V	1	292P68392	56289	0160-0166	1
C11	fxd, polyester 2200pF 200V	1	AE12C222KT	06001	0160-0154	1
C12	fxd, cer. 5000pF 1kV	2	C023B102G502ZS31	56289	0160-0899	1
C13	fxd, elect. 180μF 40V	1	672D119-DSY	56289	0180-2606	1
C14	fxd, elect. 10μF 20V		150D106X9020B2	56289	0180-0374	
C15	fxd, cer. 5000pF 1kV		C023B102G502ZS31	56289	0160-0899	
C16	fxd, elect. 69μF 150V	1	672D120-DSY	56289	0180-2607	1
C17	fxd, polyester 1μF 600V	1	1041	09134	0170-0073	1
CR1	diode, Si. 1.5A 400V	1	SR1846-12	04713	1901-0418	1
CR2	diode, stabistor 150mA 15V	3	STB523	03508	1901-0460	3
CR3	diode, Si. 200mA 80V	8	FDH6308	07263	1901-0050	6
CR4, 5	diode, Si. 100ns 1A 400V	3	1N4936		1901-1065	1
CR6, 7	diode, Si. 200mA 80V		FDH6308	07236	1901-0050	
CR8	diode, stabistor 150mA 15V		STB523	03508	1901-0460	
CR9, 10	diode, Si. 200mA 80V		FDH6308	07263	1901-0050	
CR11	diode, Si. 1A 100V	2	1N4934		1901-0693	1
CR12	diode, Si. 200mA 80V		FDH6308	07263	1901-0050	
CR13	diode, Si. 100ns 1A 400V		1N4936		1901-1065	
CR14	diode, Si. 1A 100V		1N4934		1901-0693	
CR15	diode, stabistor 150mA 15V		STB523	03508	1901-0460	
CR16, 17	diode, Si. 200mA 80V		FDH6308	07263	1901-0050	
F1	fuse, 6A 250V fast-blow	1	3102006	75915	2110-0056	5
J1, 2	connector, female, 10-pin	2	09-52-3103	27264	1251-0628	1
L1	inductor, 90μH	1		28480	5080-1846	1
Q1	SS NPN Si.	4	2N2222A		1854-0477	4
Q2	thyristor (SCR)	1	2N5060		1884-0074	1
Q3	SS NPN Si.		2N2222A		1854-0477	
Q4	power NPN Si. 10 amp	1	2N6561 (selected)	28480	5080-1850	1
Q5	power NPN Si. 4 amp	1	2N6306 (selected)	28480	5080-1851	1
Q6	power PNP Si.	1	MJE-210	04713	1853-0398	1
Q7	SS NPN Si.		2N2222A		1854-0477	
Q8	SS NPN Si.	1	MJE-200	04713	1854-0739	1
Q9	SS NPN Si.		2N2222A		1854-0477	
Q10-12	SS PNP Si.	3	2N2907A		1853-0281	3
R1	fxd, comp. 3.3 5% 1/2W	1	EB-33G5	01121	0686-0335	1
R2	fxd, film 30.1k 1% 1/8W	1	MF4C-1	19701	0757-0453	1
R3	fxd, film 3.32k 1% 1/8W	1	MF4C-1	19 701	0757-0433	1

Note 1: This assembly is designed for component-level repair. Replacement assemblies cannot be supplied.

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R4	fxd, met. ox. 8.2k 5% 2W	1	RG42	11502	0764-0044	1
R5	fxd, comp. 100k 5% 1/4W	1	CB-1045	01121	0683-1045	1
R6	fxd, comp. 47k 5% 1/4W	1	CB-4735	01121	0683-4735	1
R7	fxd, comp. 10k 5% 1/4W	1	CB-1035	01121	0683-1035	1
R8	fxd, comp. 100 5% 1/2W	1	EB-1015	01121	0686-1015	1
R9	fxd, comp. 100 5% 1/4W	2	CB-1015	01121	0683-1015	1
R10	fxd, ww. 750 5% 5W	1	RS-5	91637	0811-1861	1
R11	fxd, comp. 10 5% 1/2W	1	EB-1005	01121	0686-1005	1
R12	fxd, film 10k 1% 1/8W	1	MF4C-1	19701	0757-0442	1
R13	fxd, film 13.3k 1% 1/8W	1	MF4C-1	19701	0757-0289	1
R14	fxd, comp. 47 5% 1/4W	3	CB-4705	01121	0683-4705	1
R15	fxd, comp. 120 5% 1/4W	1	CB-1215	01121	0683-1215	1
R16	(jumper)					
R17	fxd, comp. 47 5% 1/4W		CB-4705	01121	0683-4705	
R18	fxd, comp. 51 5% 1/4W	1	CB-5105	01121	0683-5105	1
R19	fxd, comp. 2.7 5% 1/2W	1	EB-27G5	01121	0686-0275	1
R20	fxd, comp. 470 5% 1/4W	1	CB-4715	01121	0683-4715	1
R21	fxd, comp 18 5% 1/2W	2	EB-1805	01121	0686-1805	1
R22	fxd, ww. 1.0 5% 3W	1	RS-2B	91637	0811-1732	1
R23	fxd, comp. 18 5% 1/2W		EB-1805	01121	0686-1805	
R24	fxd, comp. 47 5% 1/4W		CB-4705	01121	0683-4705	
R25	fxd, comp. 430 5% 1/4W	1	CB-4315	01121	0683-4315	1
R26	fxd, comp. 820 5% 1/4W	1	CB-8215	01121	0683-8215	1
R27, 28	fxd, comp. 1k 5% 1/4W	3	CB-1025	01121	0683-1025	1
R29	fxd, film 34.8 1% 1/8W	1	MF4C-1	19701	0698-3434	1
R30	fxd, film 100 1% 1/8W	1	MF4C-1	19701	0757-0401	1
R31	fxd, film 1.62k 1% 1/8W	2	MF4C-1	19701	0757-0428	1
R32	fxd, comp. 82 5% 1/2W	1	EB-8205	01121	0686-8205	1
R33	fxd, film 1.62k 1% 1/8W		MF4C-1	19701	0757-0428	
R34-36	fxd, ww. 0.15 5% 3W	3	RS-2B	91637	0812-0045	1
R37	fxd, comp. 1k 5% 1/4W		CB-1025	01121	0683-1025	
R38	fxd, comp. 100 5% 1/4W		CB-1015	01121	0683-1015	
T1	pulse transformer	1		28480	5080-1809	1
TS1	thermal switch (opens at 90°C)	1	430-901	72983	3103-0017	1
U1	IC linear amplifier	1	LM301AH	27014	1820-0223	1
U2	IC linear timer	1	NE555T	18324	1826-0119	1
U3	photo-isolator	1	IL-1	50579	1990-0543	1
VR1	diode, zener 6.19V 2%	1	SZ10939-123	04713	1902-3114	1
VR2	diode, zener 7.5V 5%	1	SZ10939-146	04713	1902-0064	1
VR3	diode, zener 6.81V 5%	1	SZ10939-134	04713	1902-0048	1
VR4, 5	diode, zener 2.37V 5%	2	SZ10939-2	04713	1902-3002	2
VR6	diode, zener 28.7V 5%	1	SZ11213-272	04713	1902-0572	1
VR7	diode, zener 150V 5%	1	SZ11213-440	04713	1902-0586	1

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	A1 AC-DC Converter Assy. (Note 1) (Models 63005C and 63315D only)					
C1	(not assigned)					
C2, 3	fxd. elect. 500μF 150V	2	(Type 68D) D40701	56289	0180-1889	1
C4	fxd, cer. .01μF 100V	2	TA	91418	0150-0093	1
C5	fxd, elect. 1μF 50V	1	150D105X0050A2	56289	0180-0230	1
C6	fxd, elect. 10μF 20V	2	150D106X9020B2	56289	0180-0374	1
C7	fxd, elect. 22μF 15V	1	150D226X9015B2	56289	0180-0228	1
C8	fxd, cer. 1000pF 1kV	1	C067B102E102ZS26	56289	0150-0050	1
C9	fxd, elect. 10μF 20V		150D106X9020B2	56289	0180-0374	
C10	fxd, mica 2000pF 100V	1	obd	72136	0160-2301	1
C11	fxd, cer. .01μF 100V		TA	91418	0150-0093	
C12	fxd, polyester .068μF 200V	1	292P68392	56289	0160-0166	1
C13	fxd, elect. 69μF 150V	1	672D120-DSY	56289	0180-2607	1
C14	fxd, polyester 2200pF 200V	1	AE12C222KT	06001	0160-0154	1
C15	fxd, elect. 180μF 40V	1	672D119-DSY	56289	0180-2606	1
CR1, 2	diode, Si. 750mA 600V	2	SR1358-10	04713	1901-0029	2
CR3, 4	diode, Si. 1.5A 400V	2	SR1846-12	04713	1901-0418	2
CR5-10	diode, Si. 200mA 80V	11	FDH 6308	07263	1901-0050	6
CR11	diode, Si. 1A 100V	2	1N4934	04713	1901-0693	2
CR12	diode, Si. 750mA 400V	3	SR1358-9	04713	1901-0028	3
CR13	diode, stabistor 150mA 15V	1	STB523	03508	1901-0460	1
CR14-17	diode, Si. 200mA 80V		FDH6308	07263	1901-0050	
CR18	diode, Si. 750mA 400V		SR1358-9	04713	1901-0028	
CR19	diode, Si. 200mA 80V		FDH6308	07263	1901-0050	
CR20	diode, Si. 1A 100V		1N4934	04713	1901-0693	
CR21	diode, Si. 750mA 400V		SR1358-9	04713	1901-0028	
CR22	diode, Si. 100ns 1A 400V	1	1N4936	04713	1901-1065	1
F1	fuse, fast blow 5A 250V	1	312005	75915	2110-0010	5
J1, 2	connector, female, 10-pin	2	09-52-3103	27264	1251-0628	1
L1	inductor, 370μH	1		28480	5080-1807	1
Q1, 2	thyristor (SCR)	2	40869	02735	1884-0233	2
Q3, 4	SS NPN Si.	4	2N2222A	14433	1854-0477	4
Q5	power NPN Si.	1	2N6306 (Selected)	28480	1854-0657	1
Q6	power PNP Si.	1	MJE-210	04713	1853-0398	1
Q7	SS NPN Si.		2N2222A	14433	1854-0477	
Q8-10	SS PNP Si.	3	2N2907A	14433	1853-0281	3
Q11	SS NPN Si.		2N2222A	14433	1854-0477	
R1, 2	fxd, comp. 10 5% 1/2W	2	EB-1005	01121	0686-1005	1
R3	(not assigned)					
R4	fxd, ww 6k 5% 5W	1	243E	56289	0811-1559	1
R5	fxd, ww 3k 5% 3W	2	VAL-3	24681	0812-0010	1
R6	fxd, film 4.3k 1% 1/8W	1	MF4C-1	19701	0757-0436	1
R7	fxd, film 9.09k 1% 1/8W	1	MF7C-1	19701	0757-0288	1
R8	fxd, comp. 270k 5% 1/4W	1	CB-2745	01121	0683-2745	1
R9	fxd, comp. 20 5% 1/4W	1	CB-2005	01121	0683-2005	1
R10	fxd, comp. 1.6k 5% 1/4W	1	CB-1625	01121	0683-1625	1
R11	fxd, comp. 6.2k 5% 1/4W	1	CB-6225	01121	0683-6225	1
R12	fxd, comp. 160k 5% 1/4W	2	CB-1645	01121	0683-1645	1

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R13	fxd, comp. 4.3k 5% 1/4W	1	CB-4325	01121	0683-4325	1
R14	fxd, comp. 160k 5% 1/4W		CB-1645	01121	0683-1645	
R15	fxd, comp. 1k 5% 1/4W	2	CB-1025	01121	0683-1025	1
R16, 17	fxd, comp. 10k 5% 1/4W	3	CB-1035	01121	0683-1035	1
R18	fxd, film 39k 1% 1/8W	1	CMF-55-1, T-1	91637	0698-6076	1
R19	fxd, film 100k 1% 1/8W	1	MF4C-1	19701	0757-0465	1
R20	fxd, film 6.49k 1% 1/8W	1	MF4C-1	19701	0698-3226	1
R21	fxd, ww, 3k 5% 5W	1	243E	56289	0812-0050	1
R22	fxd, comp. 100 5% 1/2W	1	EB-1015	01121	0686-1015	1
R23	fxd, comp. 100 5% 1/4W	2	CB-1015	01121	0683-1015	
R24	fxd, film 3.83k 1% 1/8W	1	MF4C-1	19701	0698-3153	1
R25	fxd, film 16.2k 1% 1/8W	1	MF4C-1	19701	0757-0447	1
R26	fxd, comp. 100 5% 1/4W		CB-1015	01121	0683-1015	
R27	fxd, comp. 47 5% 1/4W	1	CB-4705	01121	0683-4705	1
R28	fxd, comp. 18 5% 1/2W	2	EB-1805	01121	0686-1805	1
R29	fxd, comp. 820 5% 1/4W	1	CB-8215	01121	0683-8215	1
R30	fxd, comp. 18 5% 1/2W		EB-1805	01121	0686-1805	
R31	fxd, comp. 1k 5% 1/4W		CB-1025	01121	0683-1025	
R32	fxd, comp. 430 5% 1/4W	1	CB-4315	01121	0683-4315	1
R33	fxd, ww. 3 5% 3W	1	242-E	56289	0811-1224	1
R34, 35	fxd, ww. 1.5 5% 3W	3	7/16-A-54-F	44655	0811-1220	1
R36	fxd, comp. 10k 5% 1/4W		CB-1035	01121	0683-1035	
R37	fxd, ww. 0.1 10% 3W	1	K46505	14841	0811-1827	1
R38	fxd, film 30.1 1% 1/8W	1	MF4C-1	19701	0757-0388	1
R39	fxd, film 5.11k 1% 1/8W	2	MF4C-1	19701	0757-0438	1
R40	fxd, film 243 1% 1/4W	1	MF52C-1	19701	0757-0720	1
R41	fxd, film 5.11k 1% 1/8W		MF4C-1	19701	0757-0438	
R42	fxd, ww. 1.5 5% 3W		7/16-A-54-F	44655	0811-1220	
R43	fxd, ww. 3k 5% 3W		VAL-3	24681	0812-0010	
R44	fxd, comp. 10 5% 1/4W	1	CB-1005	01121	0683-1005	1
RV1	varistor, metal oxide	1		28480	0837-0129	1
T1	pulse transformer, preregulator	1		28480	5080-1808	1
T2	pulse transformer, clock	1		28480	5080-1809	1
TS1	thermal switch (opens at 110°C)	1		28480	3103-0049	1
U1	IC, thyristor-transistor array	1	CA3097E	02735	1858-0046	1
U2	IC, linear timer	1	NE555T	18324	1826-0119	1
U3	photo-isolator	1	IL-1	50579	1990-0543	1
U4	filter, RFI	1	F1798	05245	9135-0036	1
VR1	diode, zener 6.19V 5%	1	CD35646	15818	1902-0049	1
VR2	diode, zener 14.7V 5%	1	CD35754	15818	1902-3203	1
VR3	diode, zener 75V 5%	1	SZ11213-392	04713	1902-0661	1
VR4	diode, zener 150V 5%	1	SZ11213-440	04713	1902-0586	1
	A2 5V Switching Regulator Assy. (Note 1)					
C1	fxd, elect. 47μF 25V	1	672D476H025CC5B	56289	0180-0587	1
C2	fxd, elect. 2.2μF 20V	4	150D225X0020A2	56289	0180-0155	1
C3	fxd, cer. 0.1μF 50V	2	5C50B1-CML	56289	0150-0121	1
C4	fxd, polyester .022μF 200V	1	AE17C223KT	06001	0160-0162	1

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
C5	fxd, elect. 2000μF 10V	2	302GJ202U010B	00853	0180-2624	1
C6	(not assigned)					
C7, 8	fxd, elect. 2.2μF 20V		150D225X0020A2	56289	0180-0155	
C9	fxd, elect. 22μF 15V	1	150D226X9015B2	56289	0180-0228	1
C10	fxd, elect. 4.7μF 35V	1	150D475X9035B2	56289	0180-0100	1
C11	fxd, elect. 2.2μF 20V		150D225X0020A2	56289	0180-0155	
C12	fxd, elect. 2000μF 10V		302GJ202U010B	00853	0180-2624	
C13	(not assigned)					
C14	fxd, polyester .068μF 200V	1	292P68392-PTS	56289	0160-0166	1
C15	fxd, cer. 0.1μF 50V		5C50B1-CML	56289	0150-0121	
C16	fxd, cer. 2.2μF 50V (Models 61005C and 61315D only)	1	5C15C2-CML	56289	0160-0128	1
C16	fxd, cer. 1.0μF 25V (Models 63005C and 63315D only)	1	5C15C2-CML	56289	0160-0127	1
C17-19	fxd, cer. .05μF 400V	3	33C17A3-CDH	56289	0150-0052	1
C20	fxd, cer. 1000pF 1kV	1	C067B102E102ZS26	56289	0150-0050	1
CR1-5	diode, Si. 200mA 80V	5	FDH 6308	07263	1901-0050	5
L1	inductor, 123μH	1		28480	5080-1810	1
L2	inductor, 8.2μH	1	1537-34	99800	9140-0105	1
L3	inductor, 5μH	1		28480	5080-1811	1
P1	connector, male, 10-cond. (P1 is in 61315D and 63315D only)	1	09-64-1103	27264	1251-0629	1
Q1	SCR (including mica insulator)	1	2N4441	04713	1884-0082	1
Q2	SS PNP Si	1	2N2907A	14433	1853-0281	1
R1	fxd, comp. 10 5% 1/4W	2	CB-1005	01121	0683-1005	1
R2	fxd, comp. 470 5% 1/4W	3	CB-4715	01121	0683-4715	1
R3	fxd, comp. 75 5% 1/2W	1	EB-7505	01121	0686-7505	1
R4	fxd, comp. 1.3k 5% 1/4W	1	CB-1325	01121	0683-1325	1
R5	fxd, comp. 4.7k 5% 1/4W	1	CB-4725	01121	0683-4725	1
R6	fxd, comp. 6.2k 5% 1/4W	1	CB-6225	01121	0683-6225	1
R7	fxd, comp. 3k 5% 1/4W	1	CB-3025	01121	0683-3025	1
R8	fxd, comp. 180 5% 1/4W	1	CB-1815	01121	0683-1815	1
R9	fxd, comp. 3.3 5% 1/4W	1	CB-33G5	01121	0683-0335	1
R10	fxd, film 2.37k 1% 1/8W	1	MF4C-1	19701	0698-3150	1
R11	fxd, comp. 47k 5% 1/4W	1	CB-4735	01121	0683-4735	1
R12	fxd, film 4.32k 1% 1/8W	1	MF4C-1	19701	0757-0436	1
R13	fxd, film 3k 1% 1/8W	2	MF4C-1	19701	0757-1093	1
R14	fxd, comp. 150k 5% 1/4W	1	CB-1545	01121	0683-1545	1
R15	fxd, film 3k 1% 1/8W		MF4C-1	19701	0757-1093	
R16	fxd, comp. 470 5% 1/4W		CB-4715	01121	0683-4715	
R17	fxd, film 21.5k 1% 1/8W	1	MF4C-1	19701	0757-0199	1
R18	fxd, film 1.5k 1% 1/8W	1	MF4C-1	19701	0757-0427	1
R19	fxd, comp. 22k 5% 1/4W	2	CB-2235	01121	0683-2235	1
R20	fxd, film 12.7 1% 1/8W	1	CEA-993	07716	0698-4356	1
R21	fxd, comp. 22k 5% 1/4W		CB-2235	01121	0683-2235	
R22	fxd, comp. 2.2k 5% 1/4W	1	CB-2225	01121	0683-2225	1
R23	fxd, comp. 470 5% 1/4W		CB-4715	01121	0683-4715	
R24	fxd, alloy .002 ohms	1		28480	5020-2519	1
R25	fxd, comp. 82k 5% 1/4W	1	CB-8235	01121	0683-8235	1
R26	fxd, comp. 100 5% 1/4W	1	CB-1015	01121	0683-1015	1

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R27	fxd, ww, 5 5% 10W	1	247E	56289	0811-1893	1
R28	fxd, film 3.32k 1% 1/8W	2	MF4C-1	19701	0757-0433	1
R29	fxd, alloy .025 ohms	1		28480	5080-1814	1
R30	fxd, film 3.32k 1% 1/8W		MF4C-1	19701	0757-0433	
R31	var 2k 10%	1	72XR2K	73138	2100-3273	1
R32	fxd, film 1.33k 1% 1/8W	1	CEA-993	07716	0757-0317	1
R33	fxd, film 5.62k 1% 1/8W	1	MF4C-1	19701	0757-0200	1
R34	var, 5k 10%	1	3386X-502	32997	2100-3207	1
R35	fxd, comp. 1k 5% 1/4W	1	CB-1025	01121	0683-1025	1
R36	fxd, comp. 330 5% 1/4W	1	CB-3315	01121	0683-3315	1
R37	fxd, comp. 10 5% 1/4W		CB-1005	01121	0683-1005	
R38, 39	fxd, comp. 27 5% 1/4W	2	CB-2705	01121	0683-2705	1
T1	magnetic core, toroid (use with W1,W2)	1	57-1590	78488	9170-0567	1
T2	power transformer (Model 61005C)	1		28480	61005-80090	1
T2	power transformer (Model 61315D)	1		28480	61315-80090	1
T2	power transformer (Model 63005C)	1		28480	63005-80095	1
T2	power transformer (Model 63315D)	1		28480	63315-80090	1
U1	IC linear timer	1	NE555T	18324	1826-0119	1
U2	diode assy.	1		28480	1906-0067	1
U3	IC linear transistor array	1	CA3046	02735	1821-0001	1
U4	IC linear voltage regulator	1	723HC	07263	1820-0196	1
VR1	diode, zener 10V 5%	1	CD35706	15818	1902-0025	1
VR2	diode, zener 5.9V 2%	1	CD35641	15818	1902-3110	1
W1, 2	jumpers (windings 2-3, 4-5 of T1)	2		28480	8150-3271	
	A3 Dual Linear Regulator Assy. (Note 1) (Models 61315D and 63315D only)					
C1	fxd, cer. 5000pF 1kV	2	C023B102G502ZS31	56289	0160-0899	1
C2	fxd, elect. 1800μF 30V	2	066JJ182U030B	00853	0180-2643	1
C3	fxd, cer. 0.1μF 50V	2	5C50B1-CML	56289	0150-0121	1
C4	fxd, mylar .022μF 200V	2	AE17C223KT	06001	0160-0162	1
C5	fxd, elect. 2.2μF 20V	2	150D225X0020A2	56289	0180-0155	1
C6, 7	fxd, cer. .01μF 100V	4	TA	91418	0150-0093	1
C8	fxd, elect. 180μF 40V	2	672D	56289	0180-2606	1
C9	fxd, cer. 0.47μF 25V	2	5C11B7-CML	56289	0160-0174	1
C10	fxd, cer. 5000pF 1kV		C023B102G502ZS31	56289	0160-0899	
C11	fxd, elect. 1800μF 30V		066JJ182U030B	00853	0180-2643	
C12	fxd, mylar .022μF 200V		AE17C223KT	06001	0160-0162	
C13, 14	fxd, cer. .01μF 100V		TA	91418	0150-0093	
C15	fxd, elect. 2.2μF 20V		150D225X0020A2	56289	0180-0155	
C16	fxd, elect. 180μF 40V		672D	56289	0180-2606	
C17	fxd, cer. 0.47μF 25V		5C11B7-CML	56289	0160-0174	
C18	fxd, cer. .01μF 1kV	1	C023A102J103MS38	56289	0150-0012	1
C19	fxd, cer. 0.1μF 50V		5C50B1-CML	56289	0150-0121	
C20, 21	fxd, cer. .05μF 400V	2	33C17A3-CDH	56289	0150-0052	1
CR1, 2	diode, Si. 750mA 400V	2	SR1358-9	04713	1901-0028	1
J1	connector, female, 10-cond.	1		28480	1251-3361	1
L1, 2	inductor	2		28480	5080-1847	1
L3, 4	inductor, ferrite bead (Q2,Q5 emitters)	2	56-590-65/4A6	02114	9170-0894	1

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
L5, 6	inductor, toroidal, 2-winding	2		28480	5080-1808	1
Q1	power NPN Si.	2	see note, page 6-10		1854-0563	2
Q2, 3	SS PNP Si.	4	2N2907A	14433	1853-0281	4
Q4	power NPN Si.		see note, page 6-10		1854-0563	
Q5	SS PNP Si.		2N2907A	14433	1853-0281	
Q6	thyristor (SCR)	1	2N4441	04713	1884-0082	1
Q7	SS PNP Si.		2N2907A	14433	1853-0281	
R1	fxd, comp. 6.8 5% 1/2W	2	EB-68G5	01121	0698-5525	1
R2, 3	fxd, comp. 39 5% 1/2W	2	EB-3905	01121	0686-3905	1
R4	fxd, comp. 10k 5% 1/2W	2	EB-1035	01121	0686-1035	1
R5	fxd, comp. 56 5% 1/2W	2	EB-5605	01121	0686-5605	1
R6	fxd, comp. 18k 5% 1/2W	1	EB-1835	01121	0686-1835	1
R7	fxd, ww. 0.39 10% 5W	2		28480	0811-3416	1
R8	fxd, comp. 100 5% 1/2W	2	EB-51G5	01121	0686-1015	1
R9	var. trmr. 2k 10%	3	72XR2K	73138	2100-3273	1
R10	fxd, comp. 2.2k 5% 1/2W	1	EB-2225	01121	0686-2225	1
R11	var. trmr. 2k 10%		72XR2K	73138	2100-3273	
R12	fxd. film 1k 1% 1/8W	3	CEA-993	07716	0757-0280	1
R13	fxd, film 2k 1% 1/8W	1	CEA-993	07716	0757-0283	1
R14	fxd, film 1k 1% 1/8W		CEA-993	07716	0757-0280	
R15	fxd, comp. 18 5% 1/2W	2	EB-1805	01121	0686-1805	1
R16	fxd, comp. 22 5% 1/2W	3	EB-2205	01121	0686-2205	1
R17	fxd, ww. 100 3% 5W	2	RS-5	91637	0812-0018	1
R18	fxd, comp. 6.8 5% 1/2W		EB-68G5	01121	0698-5525	
R19	fxd, comp. 10k 5% 1/2W		EB-1035	01121	0686-1035	
R20	fxd, comp. 56 5% 1/2W		EB-5605	01121	0686-5605	
R21	fxd, comp. 27k 5% 1/2W	1	EB-2735	01121	0686-2735	
R22	fxd, ww. 0.39 10% 5W			28480	0811-3416	
R23	var. trmr. 2k 10%		72XR2K	73138	2100-3273	
R24	fxd, comp. 100 5% 1/2W		EB-51G5	01121	0686-1015	
R25	fxd, comp. 3k 5% 1/2W	1	EB-3025	01121	0686-3025	1
R26	fxd, comp. 270 5% 1/2W	2	EB-2715	01121	0686-2715	1
R27, 28	fxd, film 3.83k 1% 1/8W	2	MF4C-1	19701	0698-3153	1
R29	fxd, comp. 3.3k 5% 1/2W	1	EB-3325	01121	0686-3325	1
R30	fxd, comp. 270 5% 1/2W		EB-2715	01121	0686-2715	
R31	fxd, comp. 470 5% 1/2W	1	EB-4715	01121	0686-4715	1
R32	fxd, comp. 75 5% 1/2W	1	EB-7505	01121	0686-7505	1
R33	(not assigned)					
R34	fxd, film 681 1% 1/8W	2	MF4C-1	19701	0757-0419	1
R35	fxd, comp. 22 5% 1/2W		EB-2205	01121	0686-2205	
R36	fxd, ww. 100 3% 5W		RS-5	91637	0812-0018	
R37	fxd, comp. 22 5% 1/2W		EB-2205	01121	0686-2205	
R38	fxd, comp. 18 5% 1/2W		EB-1805	01121	0686-1805	
R39	fxd, film 681 1% 1/8W		MF4C-1	19701	0757-0419	
R40	fxd, film 1k 1% 1/8W		CEA-993	07716	0757-0280	
U1, 2	IC linear regulator	2	723HC	07263	1820-0196	2
U3, 4	diode assy.	2		28480	1906-0067	2
VR1, 2	diode, zener 16.19V 2%	2	SZ10939-123	04713	1902-3114	2

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	A4 Chassis-Electrical (Models 63005C and 63315D only)					
L1	inductor, 16.7mH	1		28480	5080-1806	1
	A1-Mechanical (Models 61005C and 61315D only)					
	heatsink bracket (Q4, Q5, S1)	1		28480	5020-2538	
	fuseholder bracket	1		28480	5000-3128	
XF1	fuseholder	1	342014	75915	1400-0084	
	hex nut, 1/2-24, fuseholder	1		28480	2950-0038	
	lockwasher, fuseholder	1		28480	2190-0054	
	heat dissipators (Q6, Q8)	2	6025D	13103	1205-0282	
	transistor insulator (Q4, Q5)	2		28480	0340-0503	
TB1	barrier block, 8-term.	1		28480	0360-1809	
	A1-Mechanical (Models 63005C and 63315D only)					
	heatsink bracket assembly					
	heatsink bracket (Q5, S1)	1		28480	5020-2512	
	insulator (bracket mounting)	2		28480	5020-2528	
	expanding insert, brass, 6-32	2		28480	0590-0193	
	IC socket, 16-pin (U1)	1	ICN-163-S3W	06776	1200-0507	1
	heat dissipators, (Q1, 2)	2	6025D	13103	1205-0282	
	transistor insulator, molded (Q5)	1		28480	0340-0503	
TB1	barrier block, 8-term.	1		28480	0360-0680	
	barrier block jumper	2		28480	0360-0523	
XF1	fuseholder clips	2	6008-32CN	13060	2110-0269	
	terminal tab (A4L1 connections)	3		28480	1251-4180	
	A2-Mechanical					
	heatsink bracket assembly					
	heatsink bracket (U2, Q1)	1		28480	5020-2513	
	insulator (bracket mounting)	2		28480	5020-2528	
	expanding insert, brass, 6-32	2		28480	0590-0193	
	transistor insulator, molded (U2)	1		28480	0340-0503	
	transistor insulator, mica (U2)	1	734	08530	0340-0174	
	standoff .75" (L1 mount)	1		28480	0380-0091	
	shoulder washer (L1 mount)	1		28480	2190-0360	
	felt washer (L1 mount)	1		28480	3050-0697	
	terminal tab (near R31, 34)	2		28480	1251-4180	
TB2	barrier block, 5-term.	1		28480	0360-0681	
	barrier block, jumper	2		28480	0360-0523	

Table 6-3. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	A3-Mechanical (Model 63315D only)					
	heat sink bracket (Q1, Q4)	1		28480	63315-20001	
	transistor insulator, molded (Q1, Q4)	2		28480	0340-0503	
	transistor insulator, mica (Q1, Q4)	2	734	08530	0340-0174	
	heat dissipator (Q2, Q5)	2	TXBF-019-025B	98978	1205-0037	
	terminal tab (near R9, 11, 23)	3		28480	1251-4180	
TB3	barrier block, 6-term.	1		28480	0360-0590	
	barrier block jumper	3		28480	0360-0523	
	mounting nut, right angle	1		28480	1210-0092	
	Chassis-Mechanical					
	chassis (Models 61005C and 63005C)	1		28480	5000-3112	
	chassis (Models 61315D and 63315D)	1		28480	5000-3113	
	cover (Models 61005C and 63005C)	1		28480	5000-3114	
	cover (Models 61315D and 63315D)	1		28480	5000-3115	
	cover label (Model 61005C)	1		28480	7120-5439	
	cover label (Model 61315D)	1		28480	7120-5440	
	cover label (Model 63005C)	1		28480	7120-4975	
	cover label (Model 63315D)	1		28480	7120-4974	
	heatsink (Models 61005C and 63005C)	1		28480	5020-2510	
	heatsink (Models 61315D and 63315D)	1		28480	5020-2511	
	circuit board spacer rod (Models 61005C and 63005C)	2		28480	5020-2515	
	circuit board spacer rod (Models 61315D and 63315D)	2		28480	5020-2516	
	heatsink insulator (plastic film)	1		28480	5020-2527	
	barrier block cover	1		28480	0360-0551	
	Miscellaneous					
	packing carton	1		28480	9211-1175	
	carton filler	1		28480	9220-1421	
	carton filler (Models 61005C and 63005C only)	1		28480	9220-1422	
	floater pad	4		28480	9220-1423	

NOTE: Power transistors A3Q1 and A3Q4 have no direct commercial replacements. For these transistors, the Models 61315D and 63315D uses RCA 2N3055 transistors that have been selected for the following characteristics:

h_{FE} = 35 min. to 90 max. at I_C of 4A
BV_{CEO} = 75V min.
f_T = 500kHz at I_C of 40mA

SECTION VII
CIRCUIT DIAGRAMS AND COMPONENT LOCATION DIAGRAMS

The schematic diagrams in this section are arranged as follows:

Model	Circuit Board A1	Circuit Board A2	Circuit Board A3
61005C	Fig. 7-4	Fig. 7-8	
61315D	Fig. 7-4	Fig. 7-8	Fig. 7-10
63005C	Fig. 7-6	Fig. 7-8	
63315D	Fig. 7-6	Fig. 7-8	Fig. 7-10

Adjoining each sheet of the schematic is a circuit board component location diagram that shows the locations of the components on that board and also of the circled test points which appear on the schematic. (The most important test points are also marked directly on the backs of the circuit boards.) Major waveforms are also provided as a troubleshooting aid. Refer also to Figure 4-1 for a simplified schematic of the entire power supply.

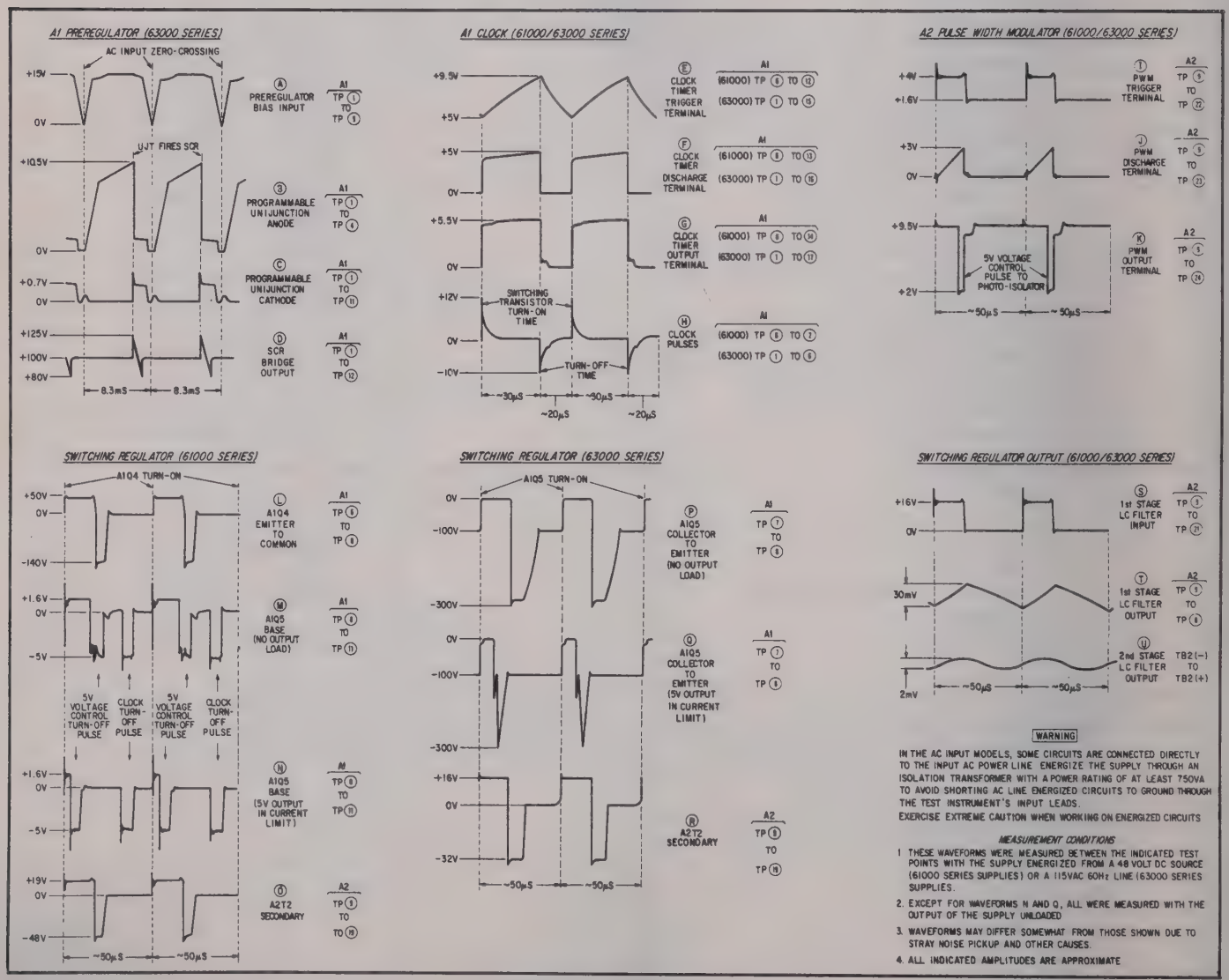

A1 PREREGULATOR (63000 SERIES)
AC INPUT ZERO-CROSSING
UJT FIRES SCR
PREREGULATOR BIAS INPUT
PROGRAMMABLE UNIJUNCTION ANODE
PROGRAMMABLE UNIJUNCTION CATHODE
SCR BRIDGE OUTPUT
8.3mS
A1 CLOCK (61000/63000 SERIES)
CLOCK TIMER TRIGGER TERMINAL
CLOCK TIMER DISCHARGE TERMINAL
CLOCK TIMER OUTPUT TERMINAL
CLOCK PULSES
SWITCHING TRANSISTOR TURN-ON TIME
TURN-OFF TIME
A2 PULSE WIDTH MODULATOR (61000/63000 SERIES)
PWM TRIGGER TERMINAL
PWM DISCHARGE TERMINAL
PWM OUTPUT TERMINAL
5V VOLTAGE CONTROL PULSE TO PHOTO-ISOLATOR
SWITCHING REGULATOR (61000 SERIES)
A1Q4 TURN-ON
A1Q4 EMITTER TO COMMON
A1Q5 BASE (NO OUTPUT LOAD)
5V VOLTAGE CONTROL TURN-OFF PULSE
CLOCK TURN-OFF PULSE
A1Q5 BASE (5V OUTPUT IN CURRENT LIMIT)
A2T2 SECONDARY
SWITCHING REGULATOR (63000 SERIES)
A1Q5 TURN-ON
A1Q5 COLLECTOR TO EMITTER (NO OUTPUT LOAD)
A1Q5 COLLECTOR TO EMITTER (5V OUTPUT IN CURRENT LIMIT)
SWITCHING REGULATOR OUTPUT (61000/63000 SERIES)
1st STAGE LC FILTER INPUT
1st STAGE LC FILTER OUTPUT
2nd STAGE LC FILTER OUTPUT
WARNING
IN THE AC INPUT MODELS, SOME CIRCUITS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER WITH A POWER RATING OF AT LEAST 750VA TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.
EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS
MEASUREMENT CONDITIONS
1. THESE WAVEFORMS WERE MEASURED BETWEEN THE INDICATED TEST POINTS WITH THE SUPPLY ENERGIZED FROM A 48 VOLT DC SOURCE (61000 SERIES SUPPLIES) OR A 115VAC 60Hz LINE (63000 SERIES SUPPLIES.
2. EXCEPT FOR WAVEFORMS N AND Q, ALL WERE MEASURED WITH THE OUTPUT OF THE SUPPLY UNLOADED
3. WAVEFORMS MAY DIFFER SOMEWHAT FROM THOSE SHOWN DUE TO STRAY NOISE PICKUP AND OTHER CAUSES.
4. ALL INDICATED AMPLITUDES ARE APPROXIMATE

Figure 7-1. Waveforms

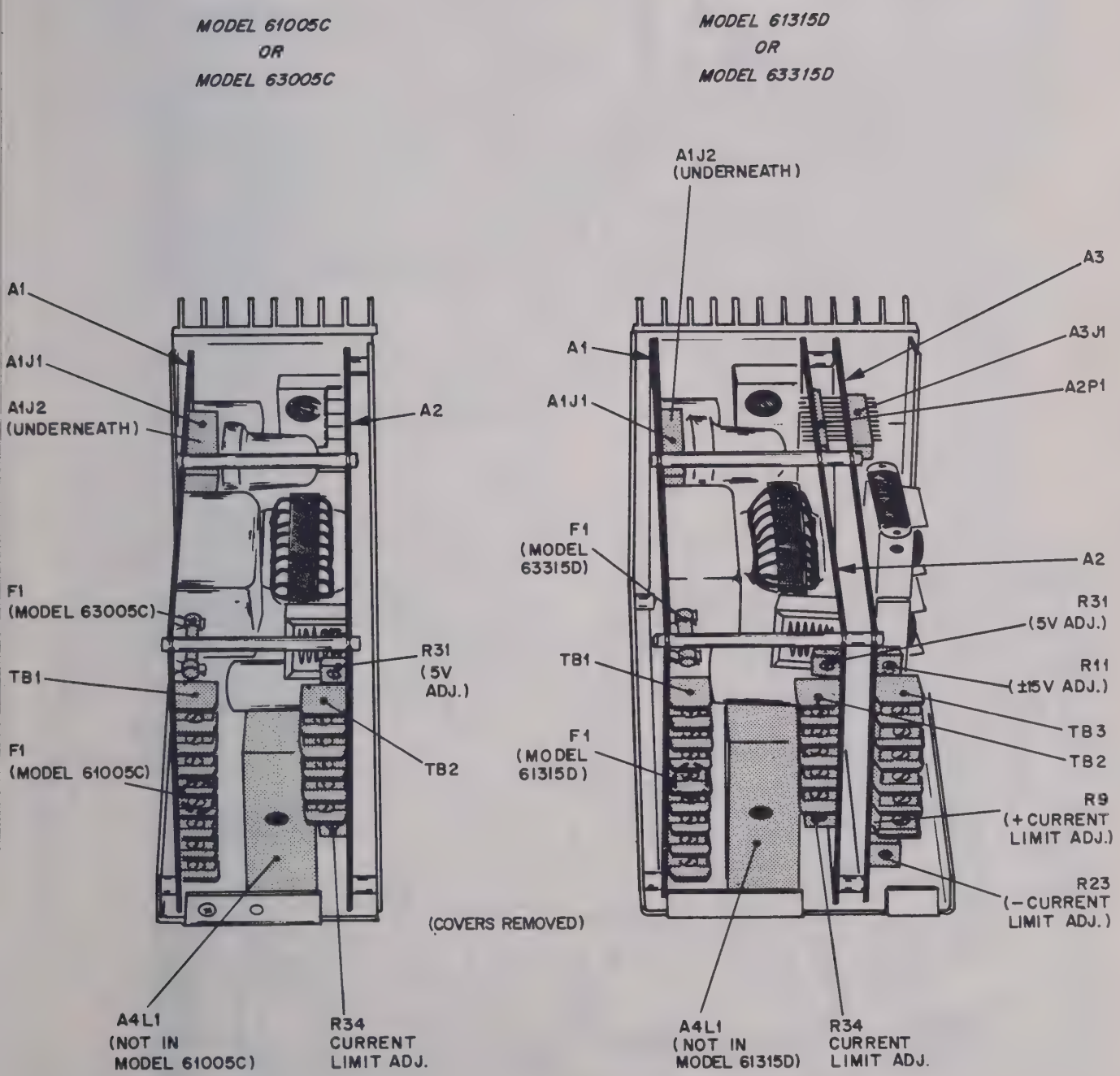
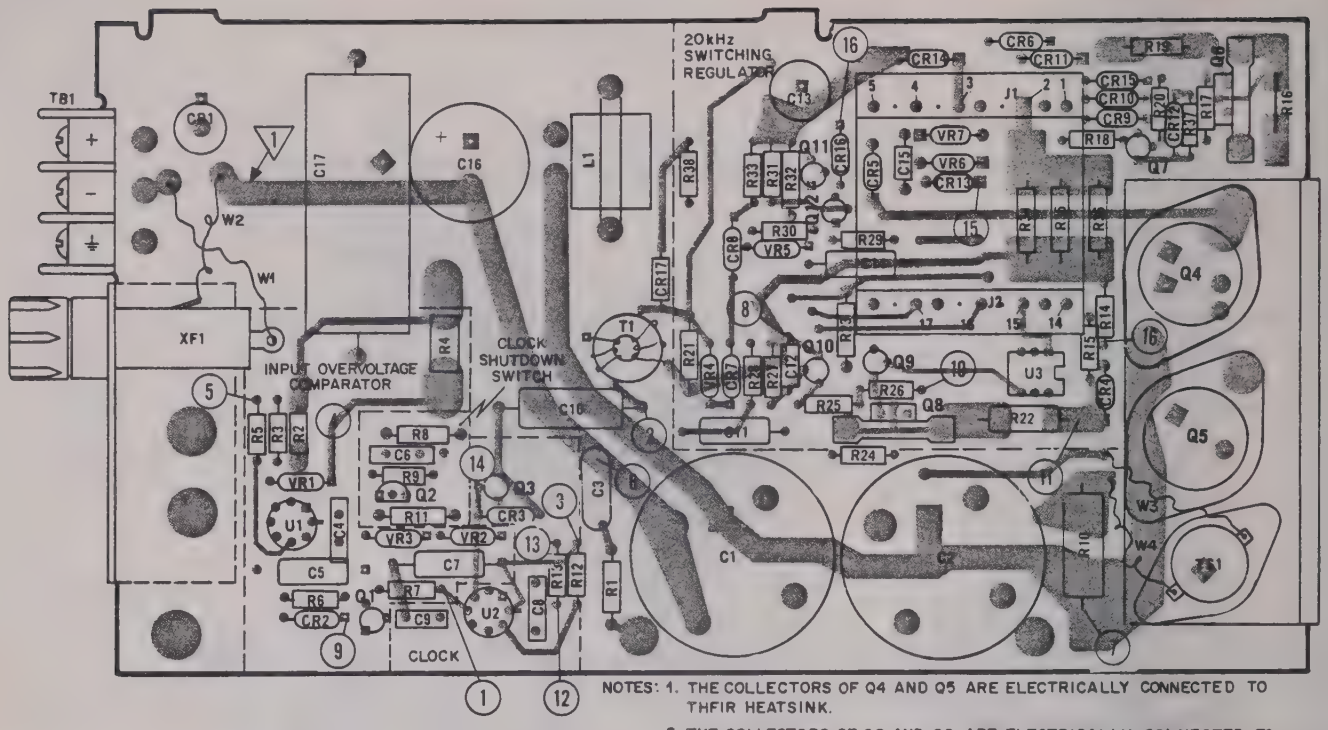


Figure 7-2. Component Locations

(COMPONENT SIDE)



NOTES: 1. THE COLLECTORS OF Q4 AND Q5 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINK.

2. THE COLLECTORS OF Q6 AND Q8 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINKS.

(CIRCUIT SIDE)

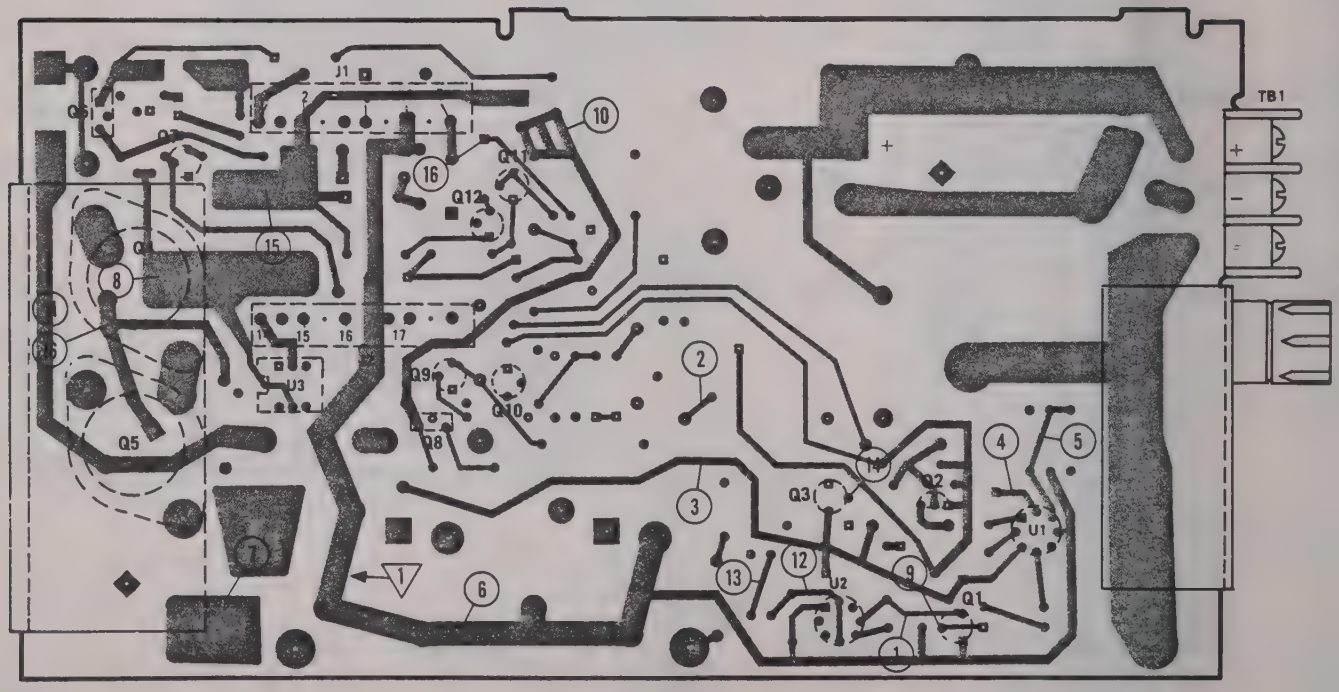


Figure 7-3. A1 DC–DC Converter Assembly, Component Locations

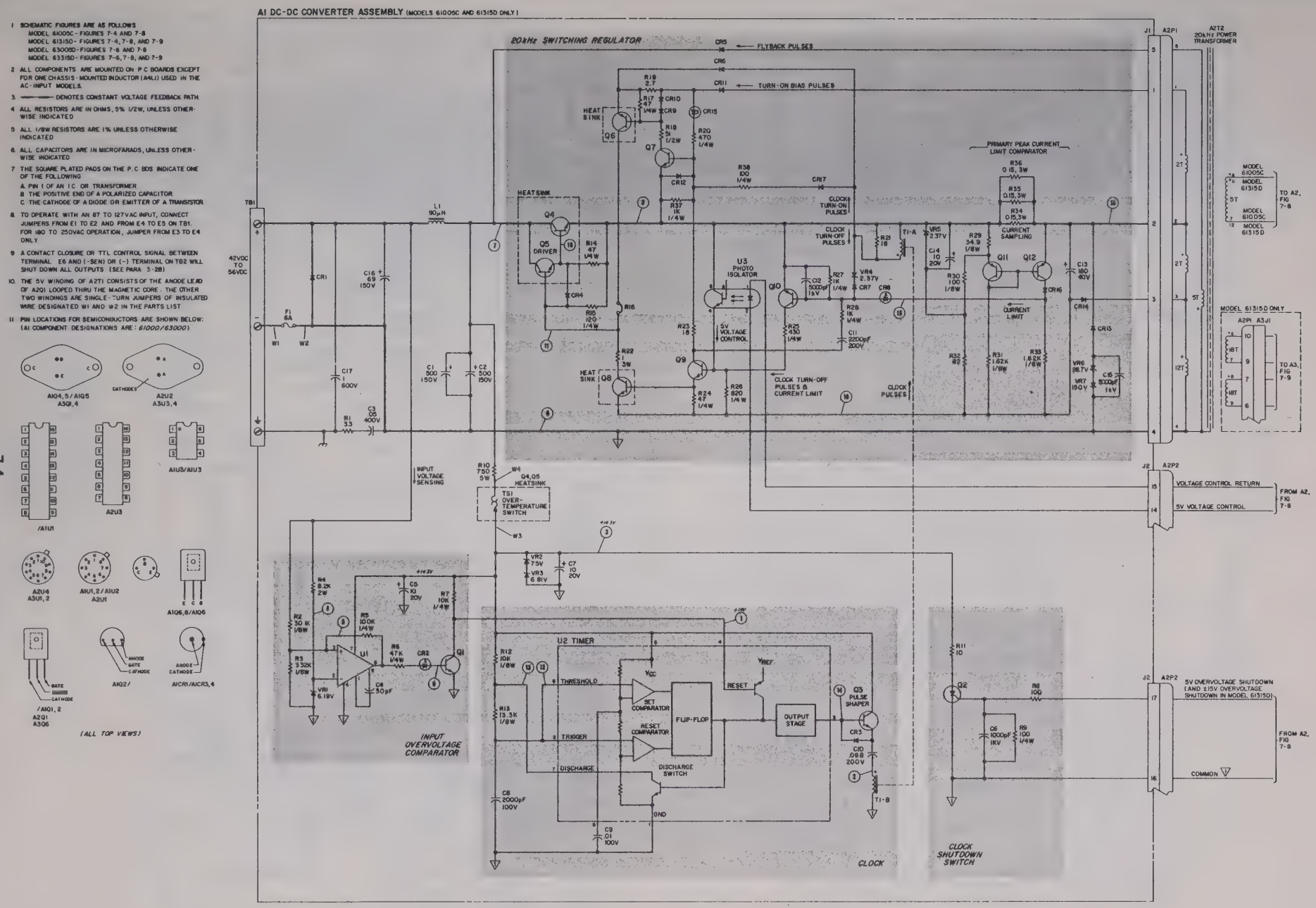
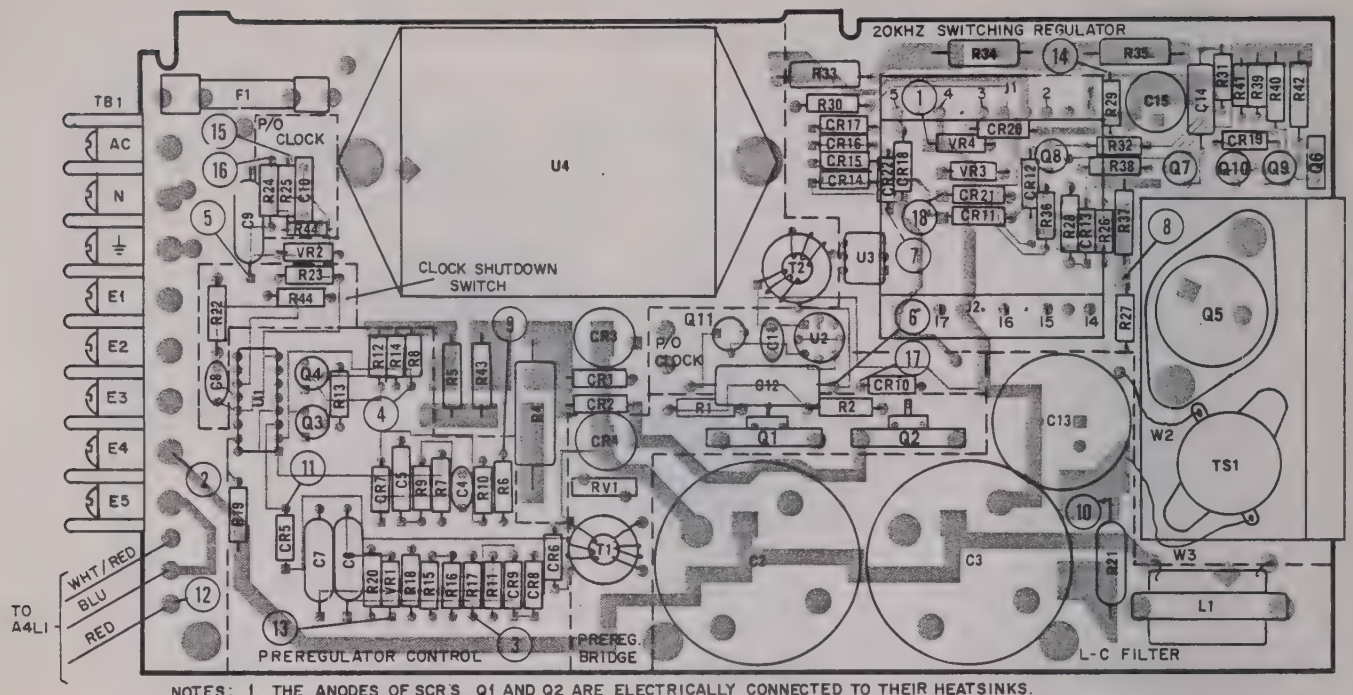

A1 DC-DC CONVERTER ASSEMBLY (MODELS 61005C AND 61315D ONLY)
1 SCHEMATIC FIGURES ARE AS FOLLOWS
MODEL 61005C - FIGURES 7-4 AND 7-8
MODEL 61315D - FIGURES 7-4, 7-8, AND 7-9
MODEL 63005D - FIGURES 7-6 AND 7-8
MODEL 63315D - FIGURES 7-6, 7-8, AND 7-9
2 ALL COMPONENTS ARE MOUNTED ON P C BOARDS EXCEPT FOR ONE CHASSIS - MOUNTED INDUCTOR (A4L1) USED IN THE AC - INPUT MODELS.
3. DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4 ALL RESISTORS ARE IN OHMS, 5% 1/2W, UNLESS OTHERWISE INDICATED
5 ALL 1/8W RESISTORS ARE 1% UNLESS OTHERWISE INDICATED
6. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED
7 THE SQUARE PLATED PADS ON THE P.C BDS INDICATE ONE OF THE FOLLOWING
A PIN 1 OF AN I C OR TRANSFORMER
B THE POSITIVE END OF A POLARIZED CAPACITOR
C THE CATHODE OF A DIODE OR EMITTER OF A TRANSISTOR
8. TO OPERATE WITH AN 87 TO 127 VAC INPUT, CONNECT JUMPERS FROM E1 TO E2 AND FROM E4 TO E5 ON TB1. FOR 180 TO 250 VAC OPERATION, JUMPER FROM E3 TO E4 ONLY
9 A CONTACT CLOSURE OR TTL CONTROL SIGNAL BETWEEN TERMINAL E6 AND (-SEN) OR (-) TERMINAL ON TB2 WILL SHUT DOWN ALL OUTPUTS (SEE PARA 3-28)
10. THE 5V WINDING OF A2T1 CONSISTS OF THE ANODE LEAD OF A2Q1 LOOPED THRU THE MAGNETIC CORE. THE OTHER TWO WINDINGS ARE SINGLE - TURN JUMPERS OF INSULATED WIRE DESIGNATED W1 AND W2 IN THE PARTS LIST
11 PIN LOCATIONS FOR SEMICONDUCTORS ARE SHOWN BELOW: (AI COMPONENT DESIGNATIONS ARE: 61000/63000)
A1Q4, 5/A1Q5 A3Q1, 4
A2U2 A3U3, 4
A1U3/A1U3
A2U3
/A1U1
A2U4 A3U1, 2
A1U1, 2/A1U2 A2U1
A1Q6, 8/A1Q6
/A1Q1, 2 A2Q1 A3Q6
A1Q2/
A1CR1/A1CR3, 4
(ALL TOP VIEWS)
20kHz SWITCHING REGULATOR
FLYBACK PULSES
TURN-ON BIAS PULSES
HEAT SINK
PRIMARY PEAK CURRENT LIMIT COMPARATOR
CLOCK TURN-ON PULSES
CLOCK TURN-OFF PULSES
CURRENT SAMPLING
CURRENT LIMIT
5V VOLTAGE CONTROL
CLOCK TURN-OFF PULSES & CURRENT LIMIT
CLOCK PULSES
INPUT VOLTAGE SENSING
Q4,Q5 HEATSINK
OVER-TEMPERATURE SWITCH
INPUT OVERVOLTAGE COMPARATOR
U2 TIMER
THRESHOLD
TRIGGER
DISCHARGE
SET COMPARATOR
RESET COMPARATOR
FLIP-FLOP
OUTPUT STAGE
DISCHARGE SWITCH
PULSE SHAPER
CLOCK
CLOCK SHUTDOWN SWITCH
42VDC TO 56VDC
A2T2 20kHz POWER TRANSFORMER
MODEL 61005C
MODEL 61315D
TO A2, FIG 7-8
MODEL 61315D ONLY
TO A3, FIG 7-9
VOLTAGE CONTROL RETURN
5V VOLTAGE CONTROL
FROM A2, FIG 7-8
5V OVERVOLTAGE SHUTDOWN (AND 2.5V OVERVOLTAGE SHUTDOWN IN MODEL 61315D)
COMMON

Figure 7-4. A1 DC—DC Converter Assembly, Models 61005C and 61315D

(COMPONENT SIDE)



NOTES: 1. THE ANODES OF SCR'S Q1 AND Q2 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINKS.
2. THE COLLECTOR OF Q5 IS ELECTRICALLY CONNECTED TO ITS HEATSINK.

(CIRCUIT SIDE)

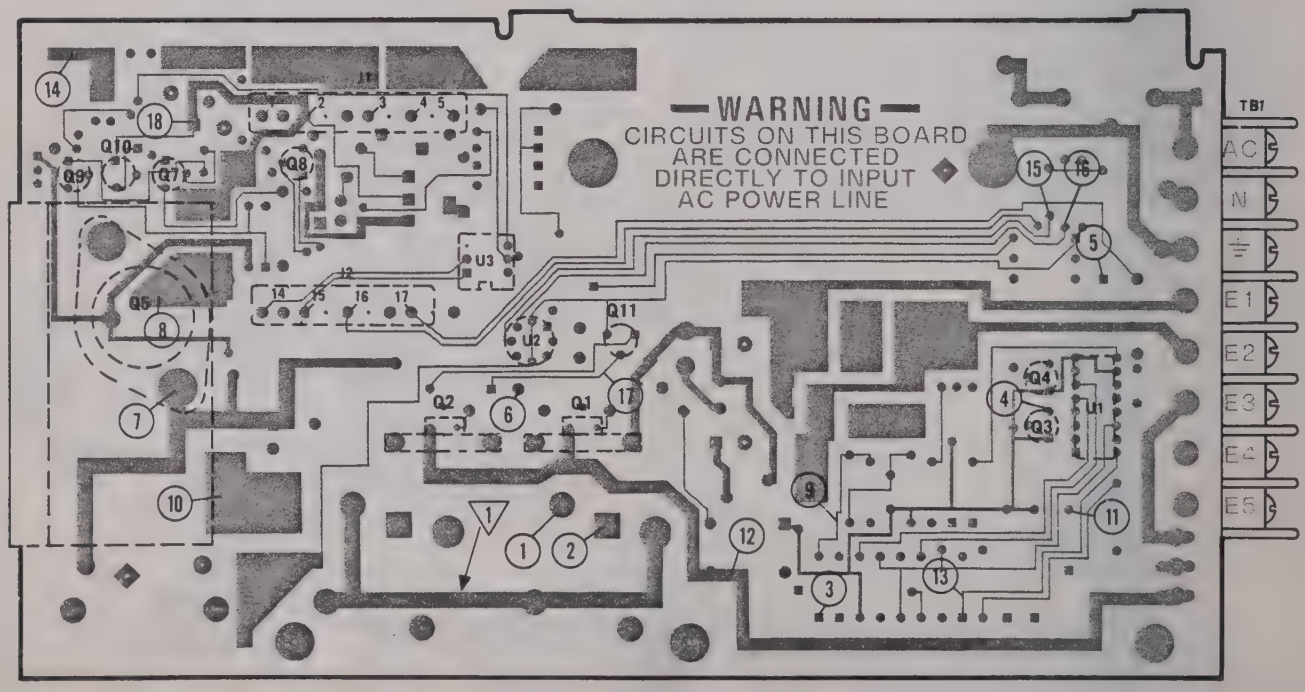


Figure 7-5. A1 AC—DC Converter Assembly, Component Locations

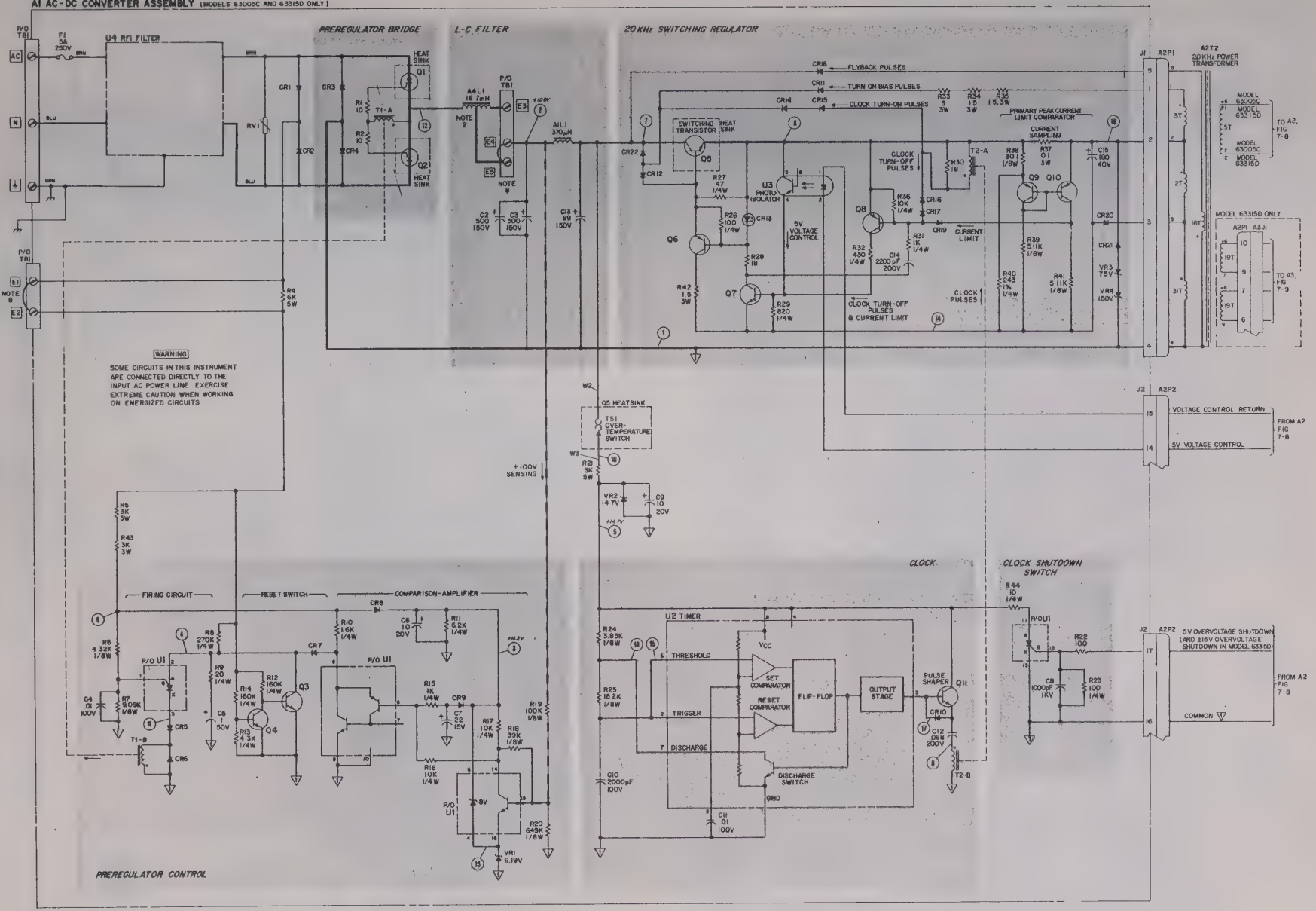


Figure 7-6. A1 AC–DC Converter Assembly, Models 63005C and 63315D

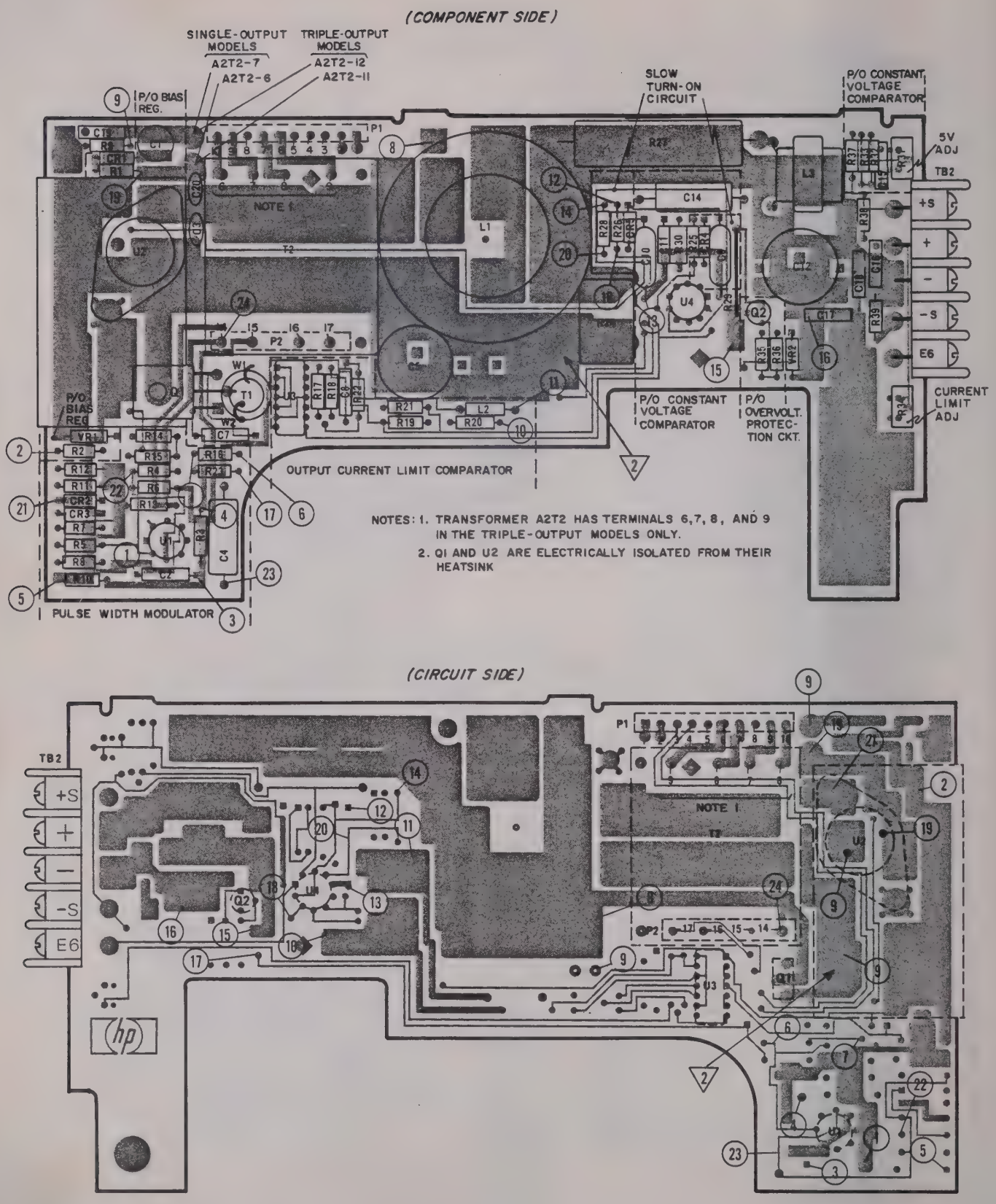


Figure 7-7. A2 5V Switching Regulator Assembly, Component Locations

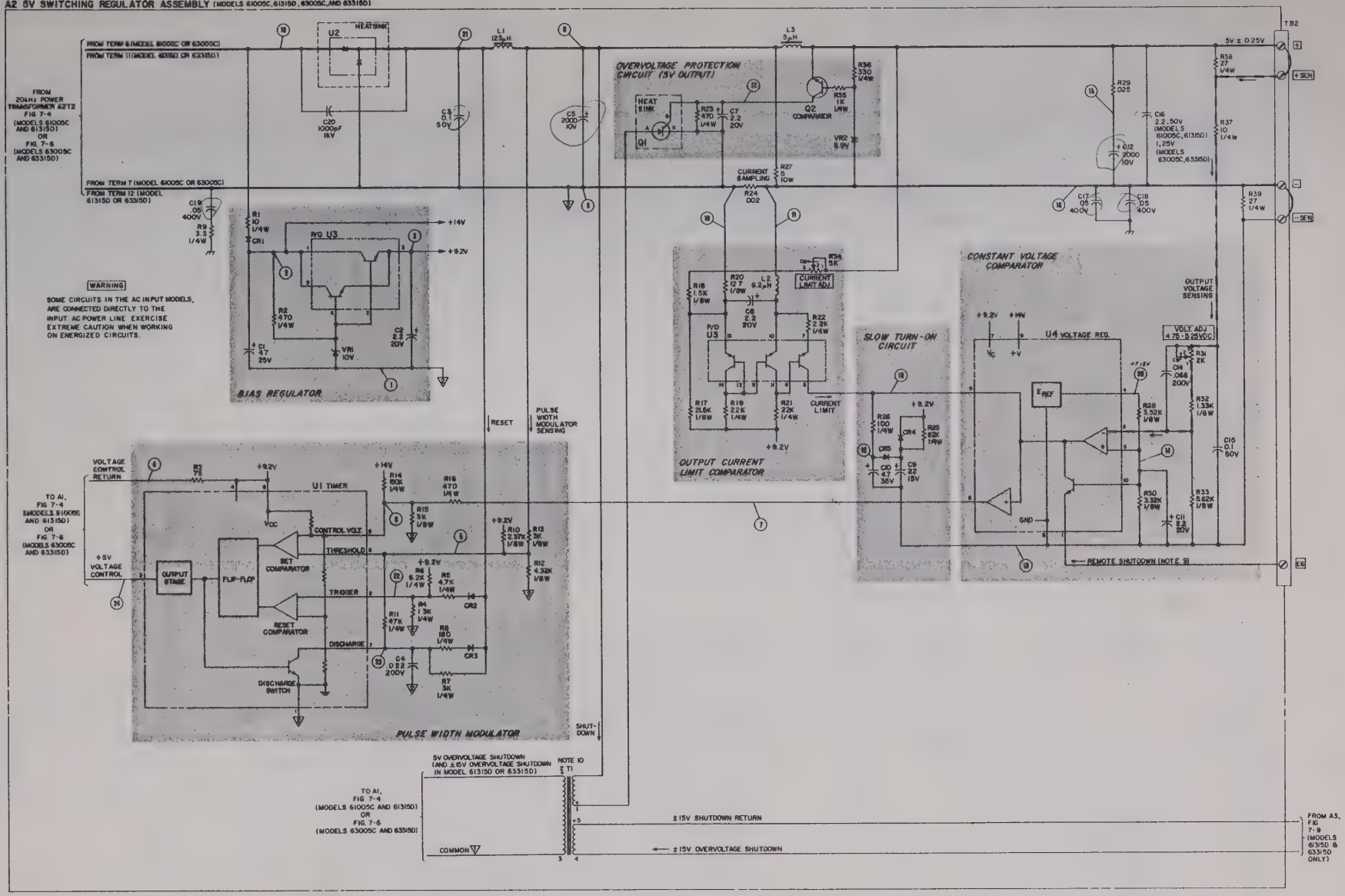

A2 5V SWITCHING REGULATOR ASSEMBLY (MODELS 61005C, 61315D, 63005C, AND 63315D)
HEATSINK
OVERVOLTAGE PROTECTION CIRCUIT (5V OUTPUT)
CONSTANT VOLTAGE COMPARATOR
SLOW TURN-ON CIRCUIT
OUTPUT CURRENT LIMIT COMPARATOR
BIAS REGULATOR
PULSE WIDTH MODULATOR
U1 TIMER
U4 VOLTAGE REG.
WARNING
SOME CIRCUITS IN THE AC INPUT MODELS, ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS.
FROM 20kHz POWER TRANSFORMER A2T3 FIG 7-4 (MODELS 61005C AND 61315D) OR FIG 7-6 (MODELS 63005C AND 63315D)
TO A1, FIG 7-4 (MODELS 61005C AND 61315D) OR FIG 7-6 (MODELS 63005C AND 63315D)
5V OVERVOLTAGE SHUTDOWN (AND ±15V OVERVOLTAGE SHUTDOWN IN MODEL 61315D OR 63315D)
±15V SHUTDOWN RETURN
±15V OVERVOLTAGE SHUTDOWN
FROM A3, FIG 7-9 (MODELS 63150 & 63315D ONLY)
REMOTE SHUTDOWN (NOTE 9)
OUTPUT VOLTAGE SENSING
VOLT ADJ 4.75-5.25VDC
5V ± 0.25V

Figure 7-8. A2 5V Switching Regulator Assembly, Models 61005C, 61315D, 63005C, and 63315D

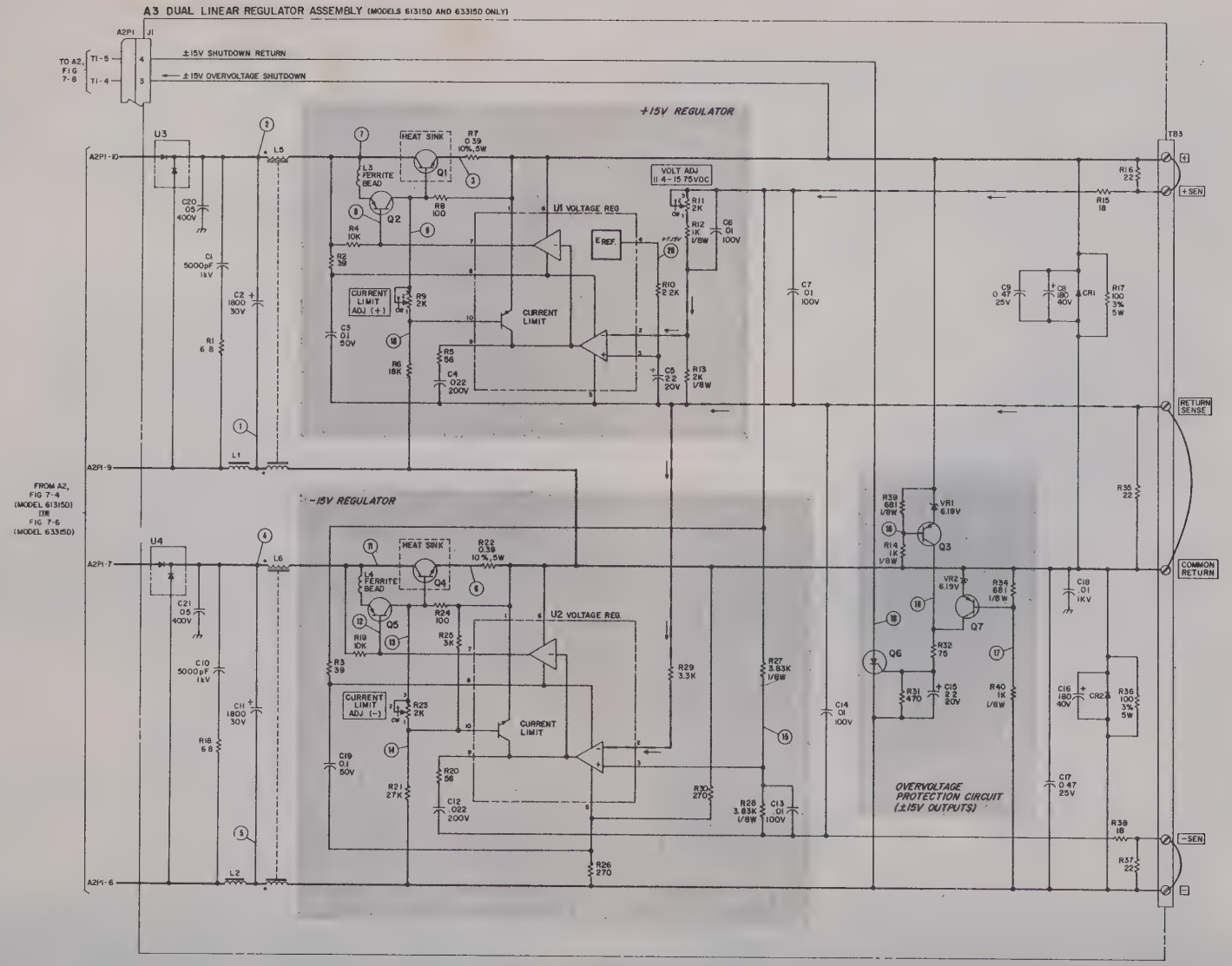
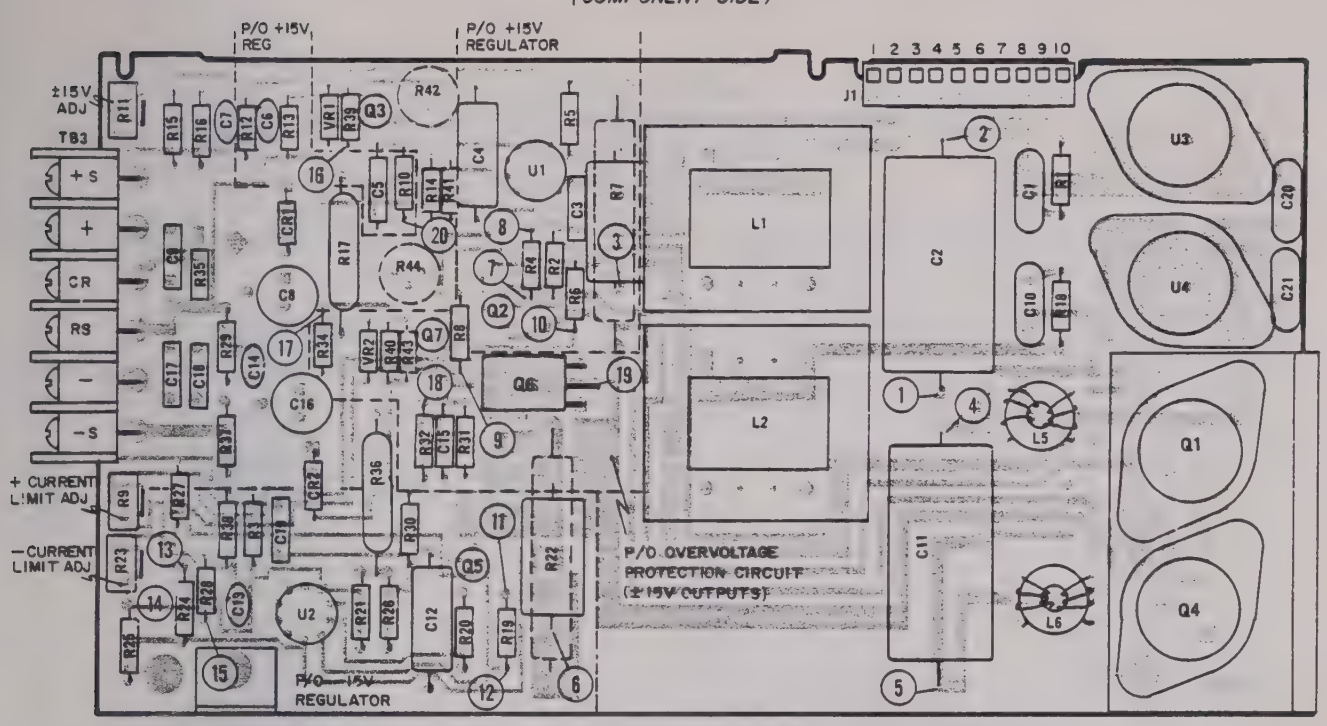


Figure 7-9. A3 Dual Linear Regulator Assembly, Models 61315D and 63315D



NOTES: 1. THE FERRITE BEADS ON THE Q2 AND Q5 EMITTER LEADS ARE DESIGNATED L3 AND L4, RESPECTIVELY.
2. RESISTORS R41 THROUGH R44 ARE NOT USED IN A STANDARD INSTRUMENT.
3. Q1 AND Q4 ARE ELECTRICALLY ISOLATED FROM THEIR HEATSINK.

Figure 7-10. A3 Dual Linear Regulator Assembly, Component Locations

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APPENDIX A
MANUAL BACKDATING CHANGES

Make the changes indicated in the table below to adapt this manual to Model 63005C or 63315D instruments with serial numbers earlier than those listed on the title page.

MODEL	SERIAL NUMBERS	MAKE CHANGES
63005C	1545A-00115 thru –00174	1
	1528A-00101 thru –00114	1, 4
63315D	1543A-00129 thru –00163	1, 2
	1528A-00101 thru –00128	1, 2, 3, 4.

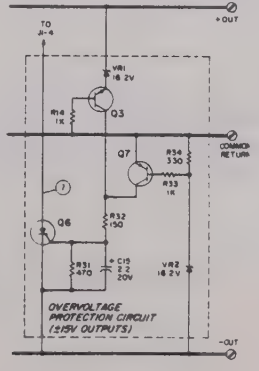
CHANGE 1: Delete capacitor A2C20.

CHANGE 2: Change capacitors A3C1 and A3C10 to .02μF, 500V, 500V, 0160-0468.

CHANGE 3: Make the following changes to the parts list and schematic for the A3 board: Change C2 and C11 to 180μF, 40V, 0180-2606. On the schematic, relocate C20 so that it is connected between the negative terminal of C2 and chassis ground. Change L1 and L2 to part number 63315-80091 and relocate item on the schematic as follows: Connect L1 in the line between the positive side of C1 and the positive side of C2; connect L2 in the line between the positive side of C10 and the positive side of C11. Change R17 and R36 to 220Ω, 5%, 2W, 0811-1763. Change R21 to 18k, 5%, 1/2W, 0686-1835. Change R25 to 5.6k, 5%, 1/2W, 0686-5625.

The following changes affect the overvoltage protection circuit on the A3 board. Substitute the schematic shown and make the following changes to the parts list: Change R14 to 1k, 5%, 1/2W, 0686-1025. Change R32 to 150Ω, 5%, 1/2W, 0686-1515. Add R33, 1k, 5%, 1/2W, 0686-1025. Change R34 to 330Ω, 5%, 1/2W, 0686-3315. Delete R39 and R40. Change VR1 and VR2 to zener, 16.2V, 1902-3214.

CHANGE 4: Add capacitors A2C6 and A2C13 in parallel with Add capacitors A2C6 and A2C13 in parallel with A2C5 and A2C12, respectively. All four of these capacitors are 1000μF, 12Vdc, 0180-0633. (The two 2000μF, 10V, 0180-2624 capacitors used for A2C5 and C6 in later units may be used interchangeably with the two pairs of 1000μF, 12V, 0180-0633 capacitors used for A2C5, C6, C12, and C13 in earlier units.)



MANUAL CHANGES

Models 61005C, 61315D, 63005C, and 63315D

Modular Power Supplies

Manual HP Part No. 5950-1774

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

Model 61005C

Serial Prefix	Serial Number	Make Changes
1812A	00236-00255	3,5,7,13
1929A	00256-00355	3,5,7,11
2116A	00356-00375	3,5,7,11
2132A	00376-up	3,5,7,11,14

Model 61315D

Serial Prefix	Serial Number	Make Changes
1633A	00133-00347	1
1802A	00348-00377	1,3
1810A	00378-00897	1,3,5,7
1849A	00898-00847	1,3,5,7
1911A	00848-01207	1,3,5,7,11
1928A	01208-01387	1,3,5,7,11
1934A	01388-01917	1,3,5,7,10,11
1948A	01918-02517	1,3,5,7,10,11,13
2036A	02518-02607	1,3,5,7,10,11,13
2048A	02608-02757	1,3,5,7,10,11,13
2105A	02758-02927	1,3,5,7,10,11,13
2125A	02928-up	1,3,5,7,10,11,13,14

Model 63005C

Serial Prefix	Serial Number	Make Changes
1733A	00650-00789	2
1733A	00790-00939	2, 3
1733A	00940-01039	2, 3, 4
1806A	01040-01189	2, 3, 4, 6
1809A	01190-02359	2, 3, 4, 6, 7
1919A	2361-2366, 2368, 2370, 2373-2374, 2377-2384, 2386, 2388-2391, 2393-2401, 2403-2414, 2416-2427, 2429-2431, 2433, 2434	2-4, 6-8
1919A	2360, 2367, 2369, 2371, 2372, 2375, 2376, 2385, 2387, 2392, 2402, 2415, 2428, 2432	2-4, 6-9
1926A	2435-2814	2-4, 6-9
1951A	2815-3344	2-4,6-9,12
2121A	3344-up	2-4,6-9,12,14

Model 63315D

Serial Prefix	Serial Number	Make Changes
1633A	00264-00553	1
1735A	00554-00643	1, 2
1735A	00644-00673	1, 2, 3
1804A	00674-00743	1, 2, 3, 4,6
1813A	00744-01163	1, 2, 3, 4, 6, 7
1917A	1164, 1166-1169, 1171, 1172, 1174-1177, 1180-1183, 1185, 1189-1193, 1196, 1198-1201, 1205-1208, 1210, 1211	1-4, 6-8
1917A	1165, 1170, 1173, 1178, 1179, 1184, 1186-1188, 1194, 1195, 1197, 1202-1204, 1209, 1212, 1213	1-4, 6-9
1920A	1214-1313	1-4, 6-9
1932A	1314-1413	1-4, 6-10
1939A	1414-1993	1-4,6-10,12
2127A	1994-up	1-4,6-10,12,14

CHANGE 1:

On page 6-8 of the parts list and the Figure 7-9 schematic of the A3 board, make the following changes:

Change A3R17 and A3R36 to 220Ω, 2W, HP Part No. 0811-1763. Add resistor A3R41, 400Ω, 5W, HP Part No. 0811-1857. On the schematic, A3R41 is connected in parallel with A3C11 (between test points TP4 and TP5). Until the existing stock of circuit boards has been used up, A3R41 is wired between an added solder lug connected to the case of A3U4 and an existing circuit board pad connected to TP5 and located between L5 and L6.

ERRATA:

Add the following notice to paragraph 1-12: "Effective December 1, 1975, extra manuals may be obtained by ordering Option 910 when ordering your instrument. The number of extra manuals depends on the number of Option 910's ordered."

The circuit designation for A3R41, added in Change 1, has been changed to A3R45.

CHANGE 2:

In the Models 63005C and 63315D only, change the HP Part No. of preregulator pulse transformer A1T1 from 5080-1808 to 5080-1785. Increased gate requirements for the preregulator SCR's (HP 1884-0233) require the use of this new transformer, therefore a new pulse transformer should also be ordered with any replacement SCR's for 63005C units with serials 1620A-00649 and below or for 63315D units with serials 1633A-00553 and below. The new transformer can be identified by the 21 turns on both windings (instead of 4 turns on the original).

CHANGE 3:

In all models, add two new capacitors (C26 and C27) to A2 Board. C26 is connected in parallel with R12 and is .001μF, 1kV, HP Part No. 0150-0050. C27 is connected from pin 9 of U4 to common ▽2 and is .01μF, 100V, HP Part No. 0150-0093. The above change ensures stability of timer U1.

CHANGE 4:

In Models 63305C and 63315D, delete U1, I. C. socket, HP Part No. 1200-0507.

CHANGE 5:

On page 6-9 (A1 Mechanical) change fuseholder from HP Part No. 1400-0084 to fuseholder body HP Part No. 2110-0564 and carrier HP Part No. 2110-0569. Change fuseholder hex nut to HP Part No. 2110-0569.

CHANGE 6:

AC/DC Converter Board Ass'y., A1:
Change capacitor C6 to 1μF, 3V, HP Part No. 0180-0291.
Change resistor R11 to 33kΩ, 5%, HP Part No. 0683-3335.
To parts list and on schematic (Fig. 7-6) add new capacitor C28 from junction of R5, R43 to ▽1 common. C28 is 5000pF, HP Part No. 0160-0899.
Change power rectifier diodes CR3, CR4 to 600V, HP Part No. 1901-0420.

Change SCR thyristors Q1, Q2 to HP Part No. 5080-1919.

CHANGE 7:

Change capacitor A2C26 to .002μF, 250Vac, HP Part No. 0160-2108. Add capacitor A2C28, 100pF, 1kV, HP Part No. 0150-0050 in parallel with resistor R15. Add terminal solder stud, HP Part No. 0360-1300, to use as tie points for resistor R15 and capacitor C28.

ERRATA:

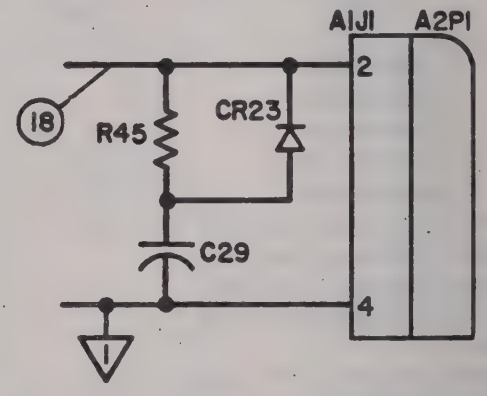
Add label, "Warning for continued protection against fire hazard . . . ", HP Part No. 7120-4627.

CHANGE 8:

On page 6-4, change the HP Part No. for A1CR18 to 1901-1065.

CHANGE 9:

On the A1 board of the Models 63005C and 63315D, CR21, VR3 and VR4 have been deleted and three new components have been added to the switching regulator circuit. They are connected as shown in the figure.



Resistor R45 is 200 ohms, ½ watt, HP part no. 0686-2015; capacitor C29 is 2000pF, 250Vac, HP Part no. 0160-2108; diode CR23 is HP Part no. 1901-1065.

Two other components have also been changed. Diode CR12 is now HP Part no. 1901-0618, and resistor R30 is now 51 ohms, ½-watt, HP Part No. 0686-5105.

CHANGE 10:

On the Figure 7-9 schematic and on page 6-8 of the parts list, change A3R4 and A3R19 to 390 ohms, 5%, 1/4W, HP Part No. 0683-3915.

ERRATA:

Change the HP Part No. for A2U2, A3U3, and A3U4 to 1906-0227.

CHANGE 11:

On page 6-2, change J1 to five individual single-contact connectors, HP Part No. 1251-5708.

CHANGE 12:

On page 6-4, change the HP Part No. of C28 to 0160-2639. The capacitor's value is unchanged. (A1C28 was added by Change 6).

CHANGE 13:

This change affects Models 61005C and 61315D only.
Make the following changes to the A1 board parts list on pages 6-2 and 6-3.
Add A1C18, 0.01μF ceramic 100V, HP Part No. 0150-0093.
Add A1CR15, Schottky diode, HP Part No. 1901-0841.
Add A1Q13, NPN transistor, HP Part No. 1854-0477.
Add A1Q14, PNP transistor, HP Part No. 1853-0281.
Add A1R39, carbon comp 27k 5% 1/4W, HP Part No. 0683-2735.
Add A1R41, carbon comp 100k 5% 1/4W, HP Part No. 0683-1045.
Delete A1CR3.
Delete A1CR15.
Change A1C12 to 5000pF 100V, HP Part No. 0160-2639.
Change A1R20 to 1.5k 5% 1/4W, HP Part No. 0683-1525.
Make the above corrections to the Figure 7-4 schematic by pasting Figure A and Figure B in place.

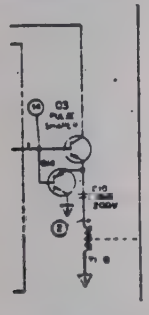


Figure A, part of Change 13

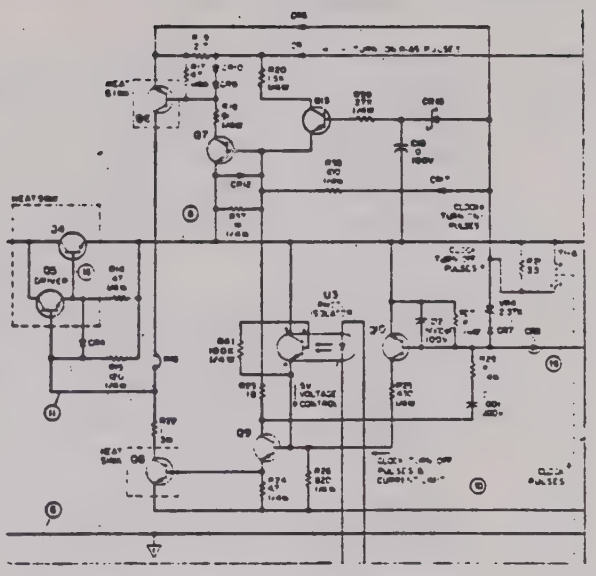


Figure B, part of Change 13

▶ CHANGE 14:

On page 6-10, **Chassis Mechanical**, change cover (Models 61005C and 63005C) to HP Part No. 61005-00001; change cover (Models 61315D and 63315D) to HP Part No. 61315-00002.

4-6-81

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KOREA

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